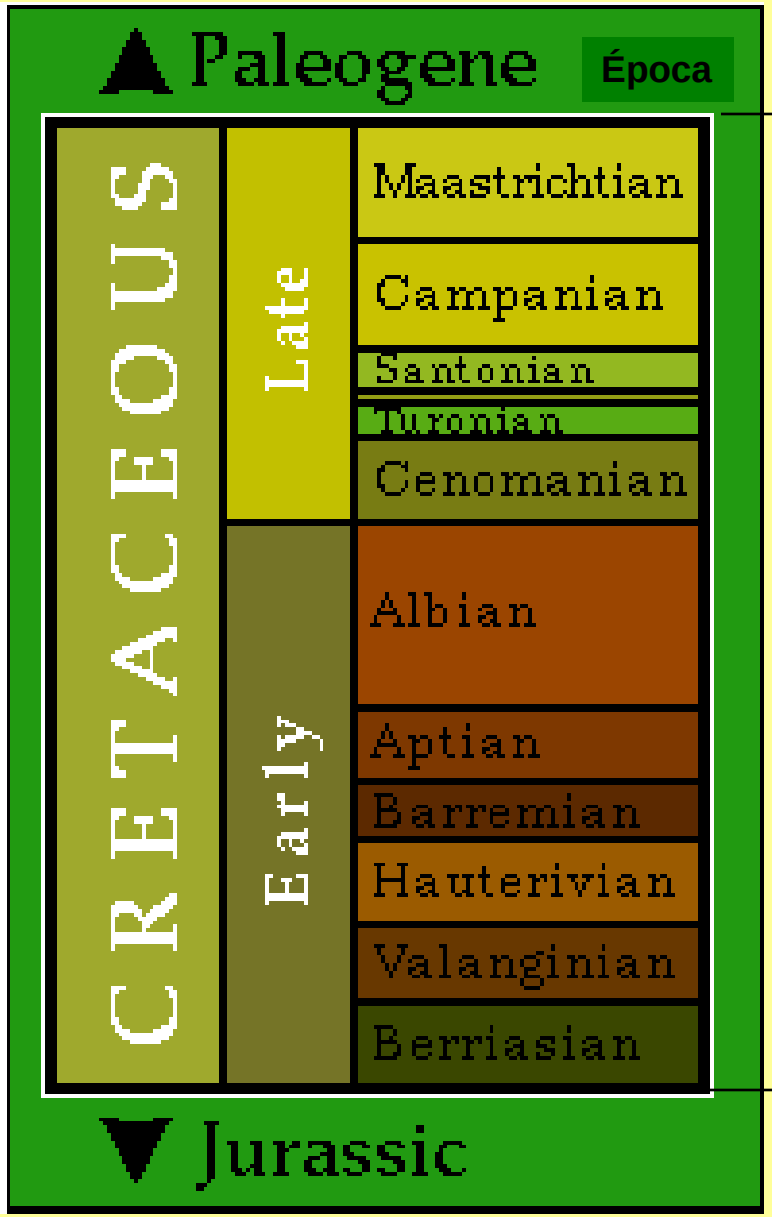
Origem e evolução das Angiospermas

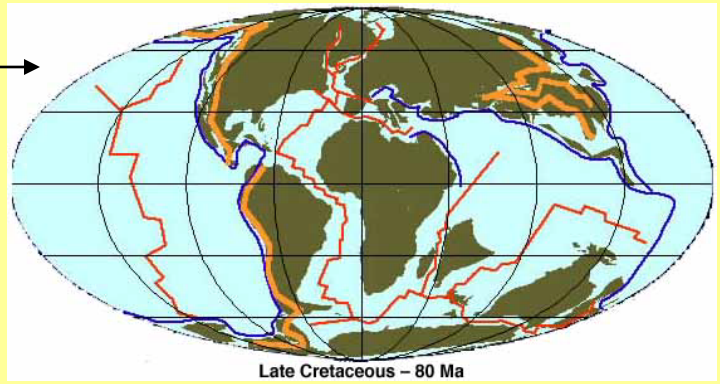
Cretáceo

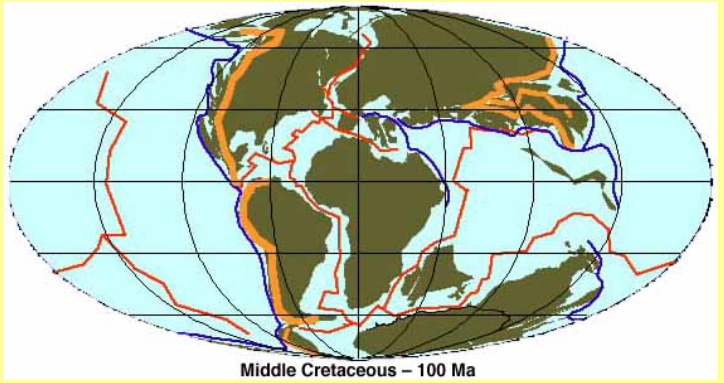
O Cretáceo

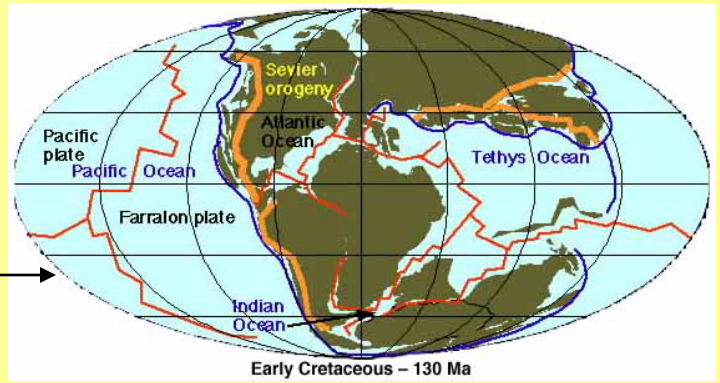
Era	Período	Época	
Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	1.6
	Tertiary	Pliocene	5
		Miocene	25
		Oligocene	34
		Eocene	58
		Paleocene	66
Mesozoic	Cretaceous		145
	Jurassic		208
	Triassic		250
Paleozoic	Permian		290
	Pennsylvanian		323
	Mississippian		362
	Devonian		408
	Silurian		439
	Ordovician		510
	Cambrian		570
Precambrian			

O Cretáceo

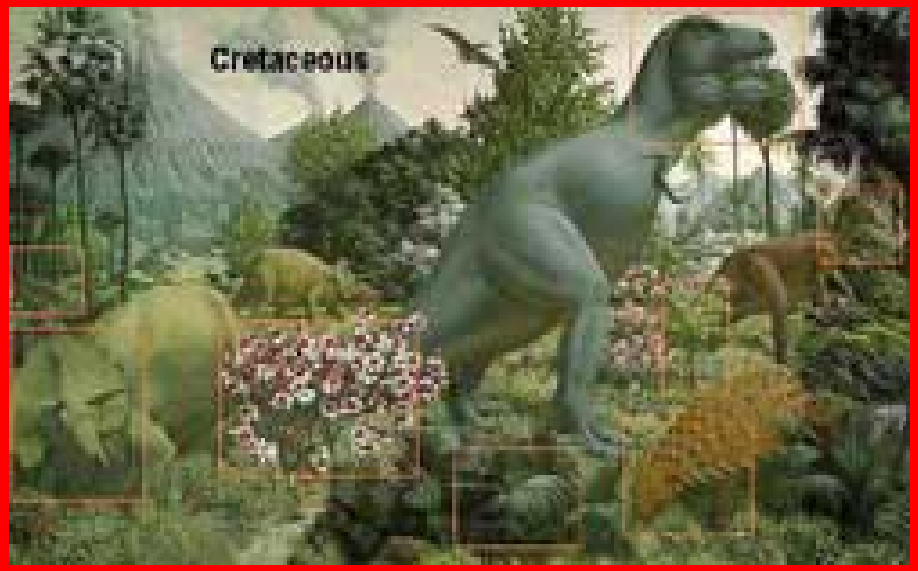

Paleogene
Época
CRETACEOUS
Late
Early
Maastrichtian
Campanian
Santonian
Turonian
Cenomanian
Albian
Aptian
Barremian
Hauterivian
Valanginian
Berriasian
Jurassic

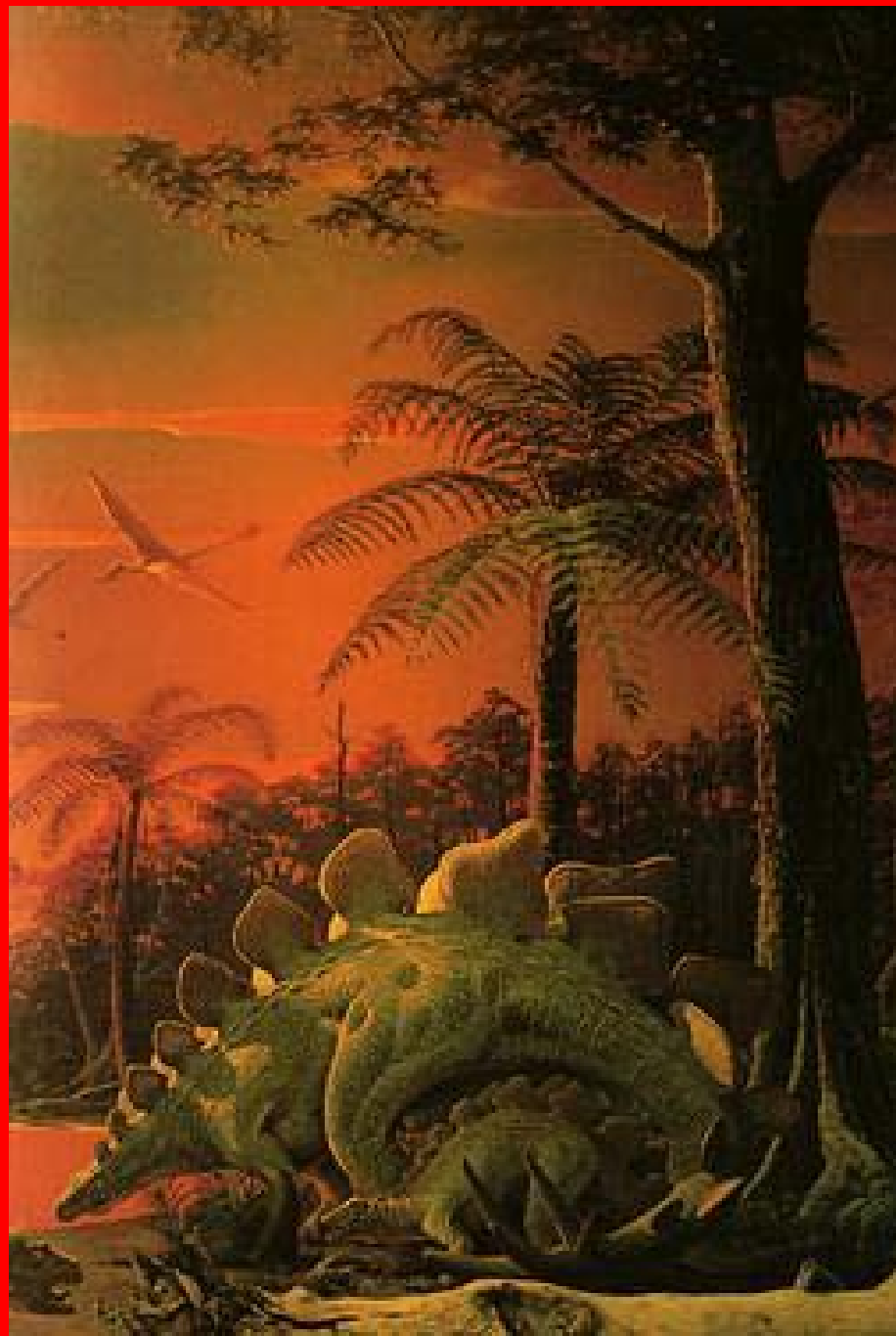

Late Cretaceous – 80 Ma


Middle Cretaceous – 100 Ma


Sevier orogeny
Atlantic Ocean
Pacific plate
Pacific Ocean
Tethys Ocean
Farralon plate
Indian Ocean
Early Cretaceous – 130 Ma

Predomínio de clima tropical e subtropical


Cretaceous

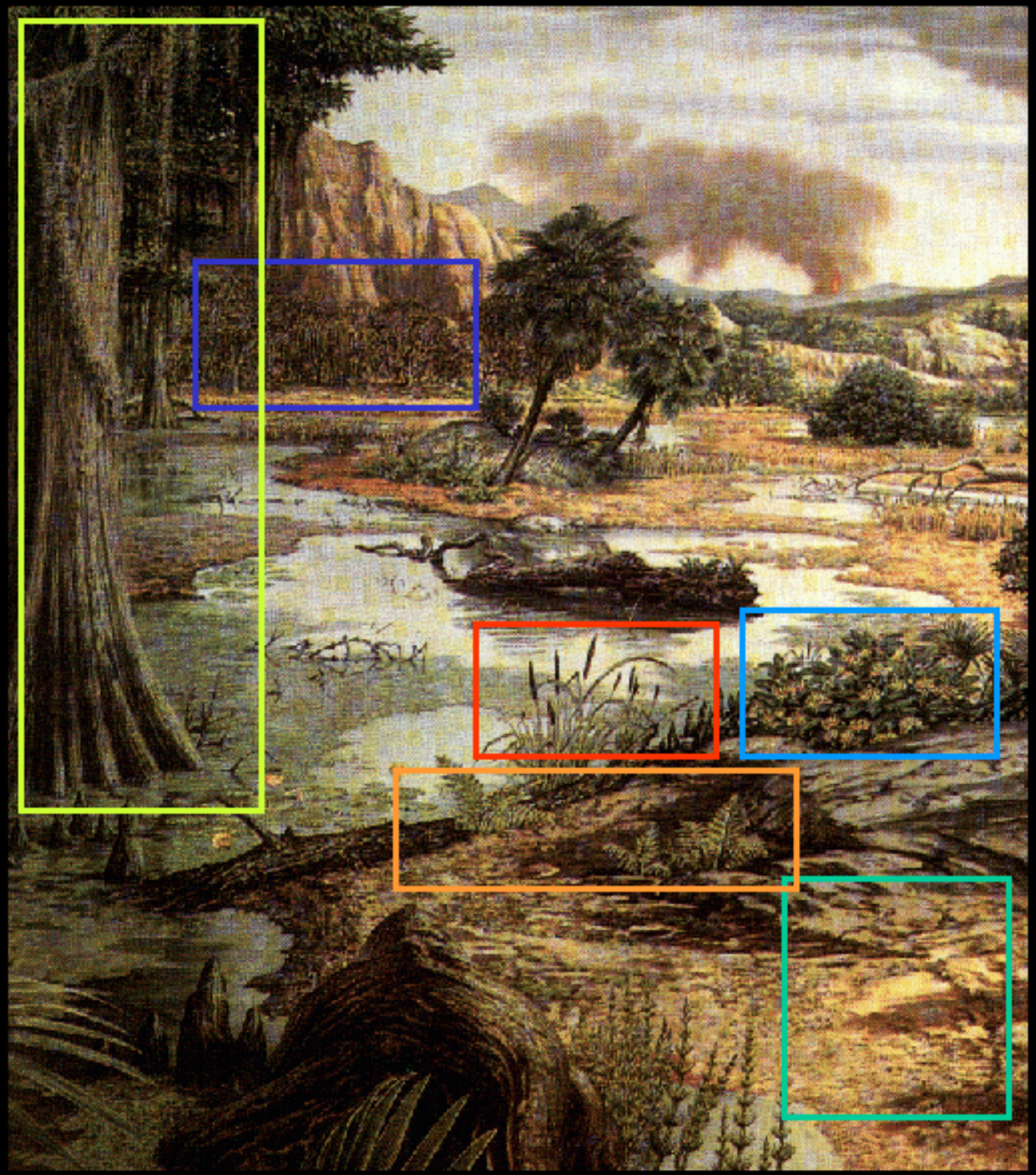


Cenário do período CRETÁCEO

- Florestas compostas de árvores com folhas amplas

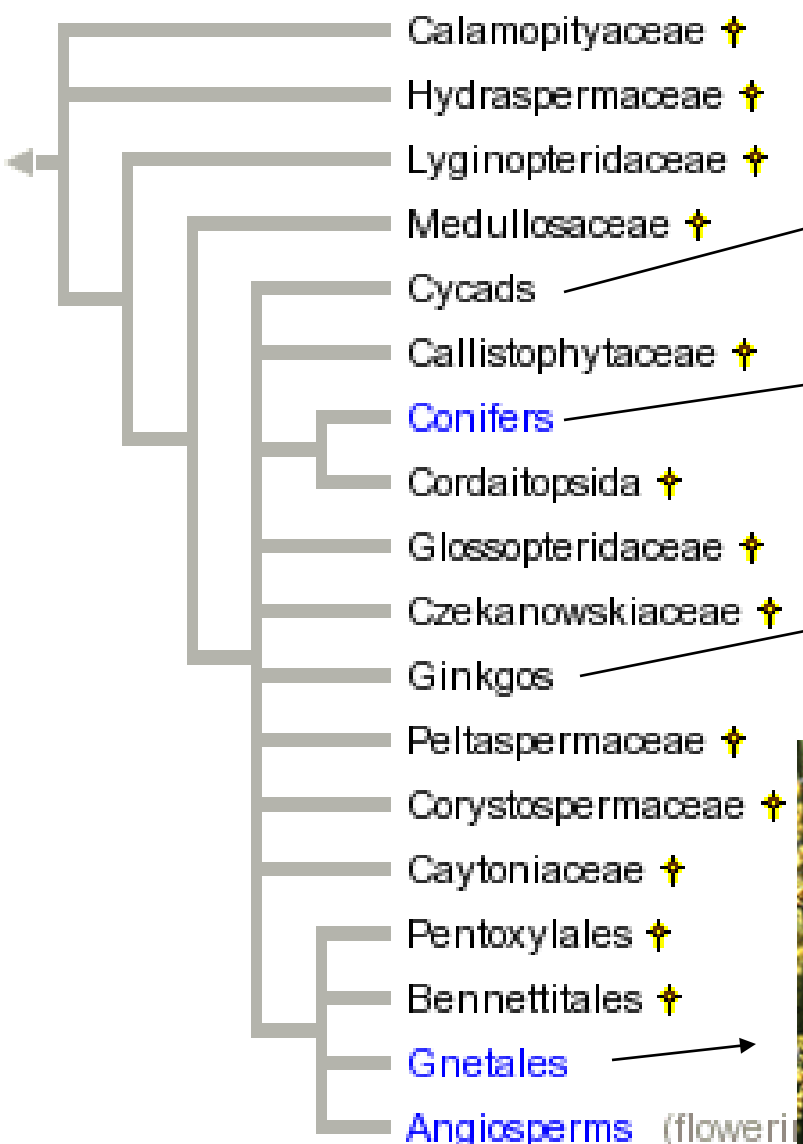
- Pântanos com ciprestes
- Líquens
- Cavalinhas
- Samambaias

- Angiospermas



Espermatófitas

(Crane 2005)



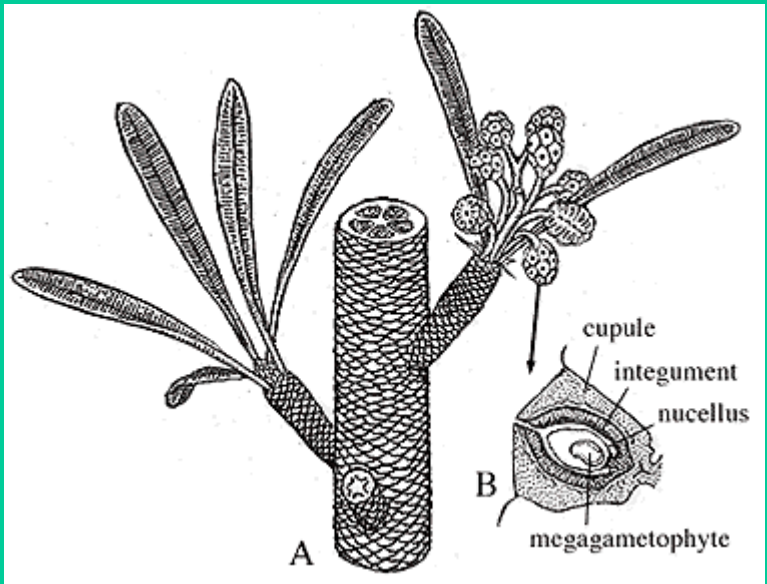
Ephedra

Welwitschia

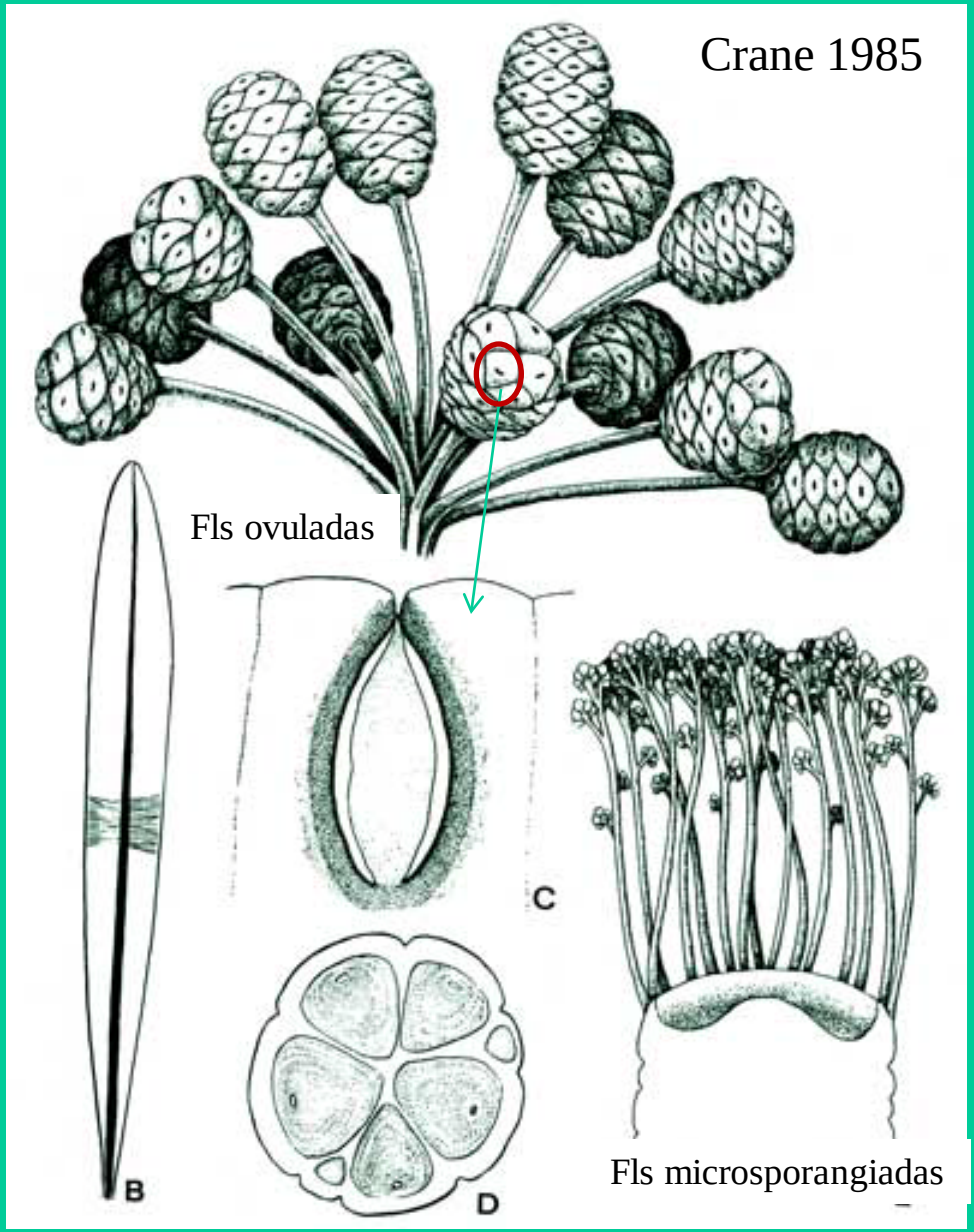
Gnetum

Plantas do cretáceo e atuais

Pentoxylales - Pentoxylaceae

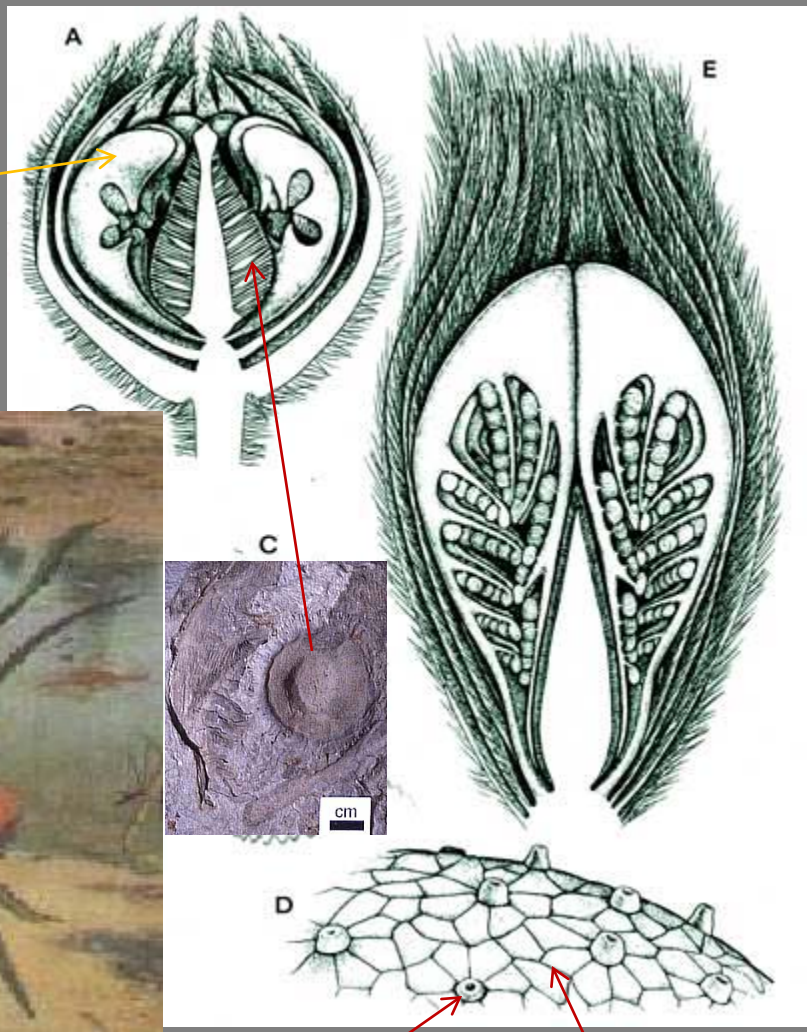


Taeniopteris lentriculiformae



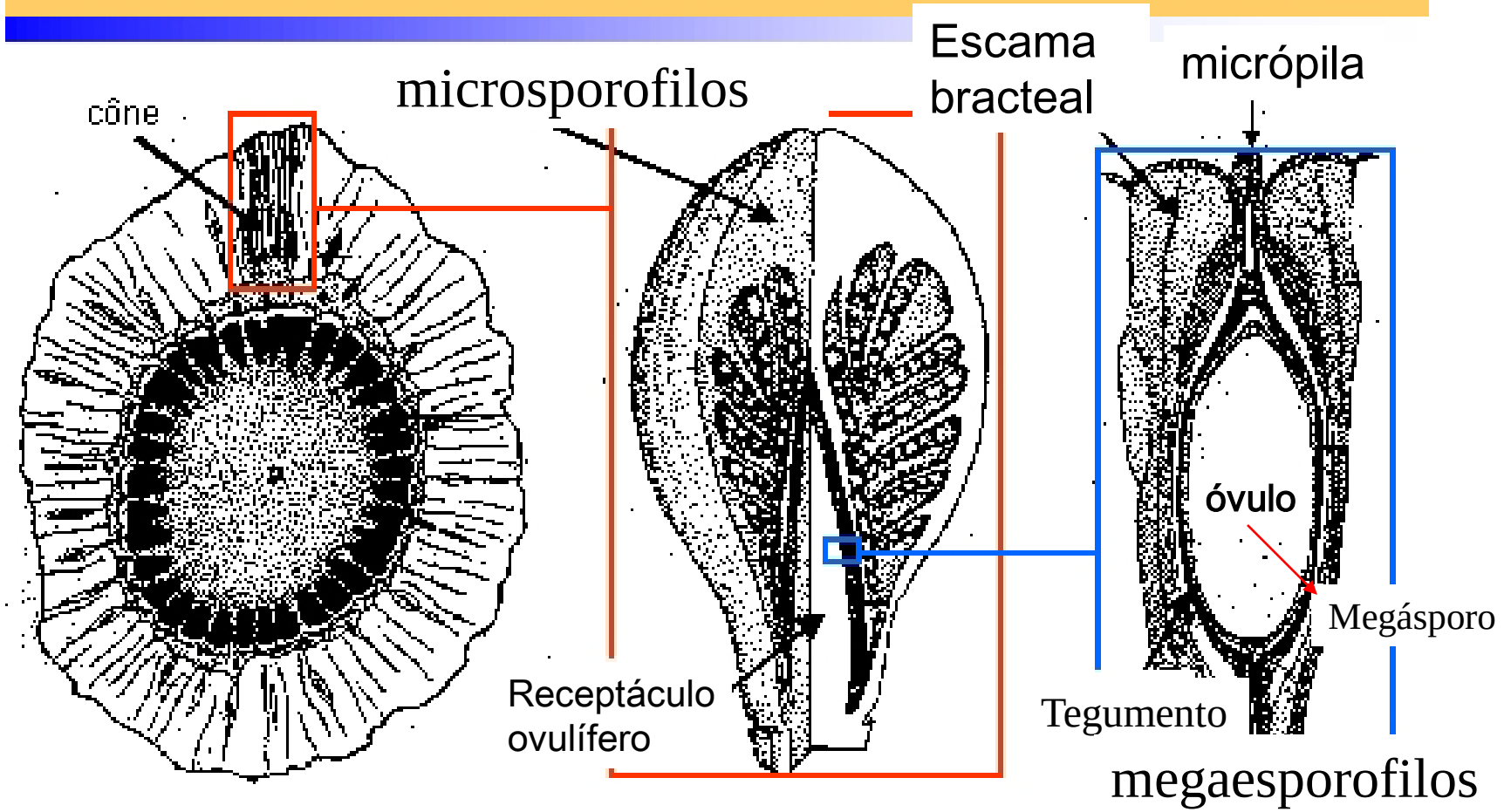
Bennettitales - Bennettitaceae

Estruturas microsporangiadas



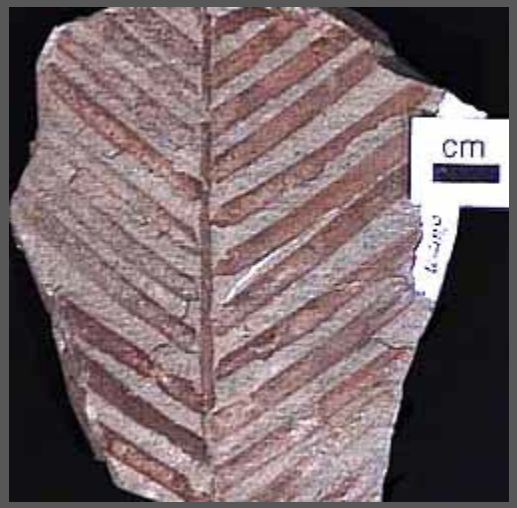
Micrópilas e escamas interseminais

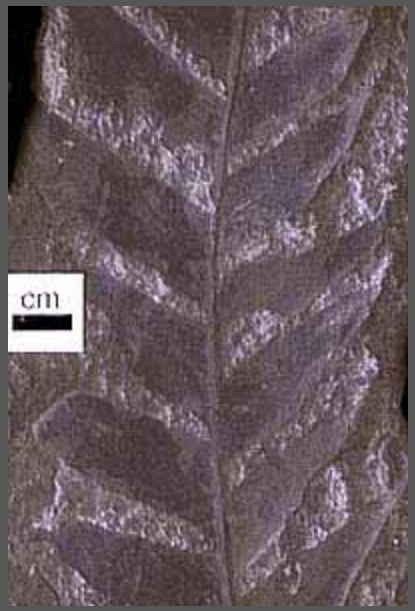
Bennettitales (2)



Corte transversal e apical do caule e a estrutura da " flor " estrobiliforme

Benettitales





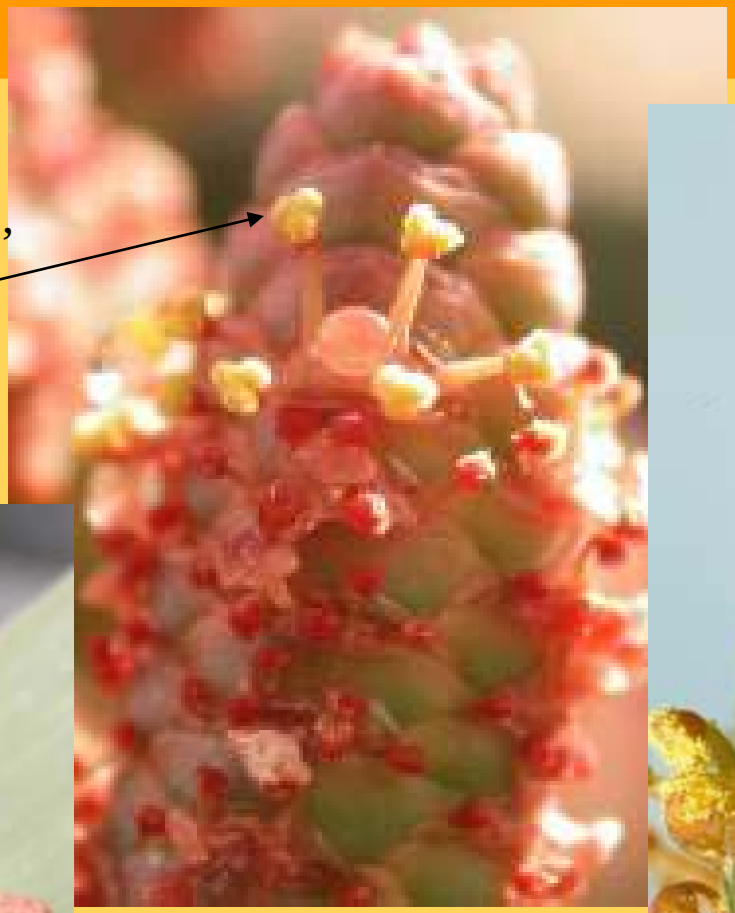
http://www.ucmp.berkeley.edu/IB181/VPL/Cup/CupVGII.html

Gnetales - *Welwitschiaceae*

Gnetales - *Welwitschiaceae*

Gnetales - *Welwitschia*

Microesporângios
Sobre microsporangióforo,
"estame funcional"



Brácteas

Cone ou "flor funcional" formada por
2 bracteolas e estames

Gnetales - *Welwitschia*

Micrópila no
Ápice do integumento
“Estigmas funcionais”

Flores femininas produzem néctar e são polinizadas por hemípteros,
Possuem óvulo (megagametófito + integumento) cujo tegumento alongado forma um “estígma” com micrópila apical, que apresenta secreção para facilitar a aderência do pólen. Bracteolas basais envolvem o óvulo.

Gnetales - Gnetaceae

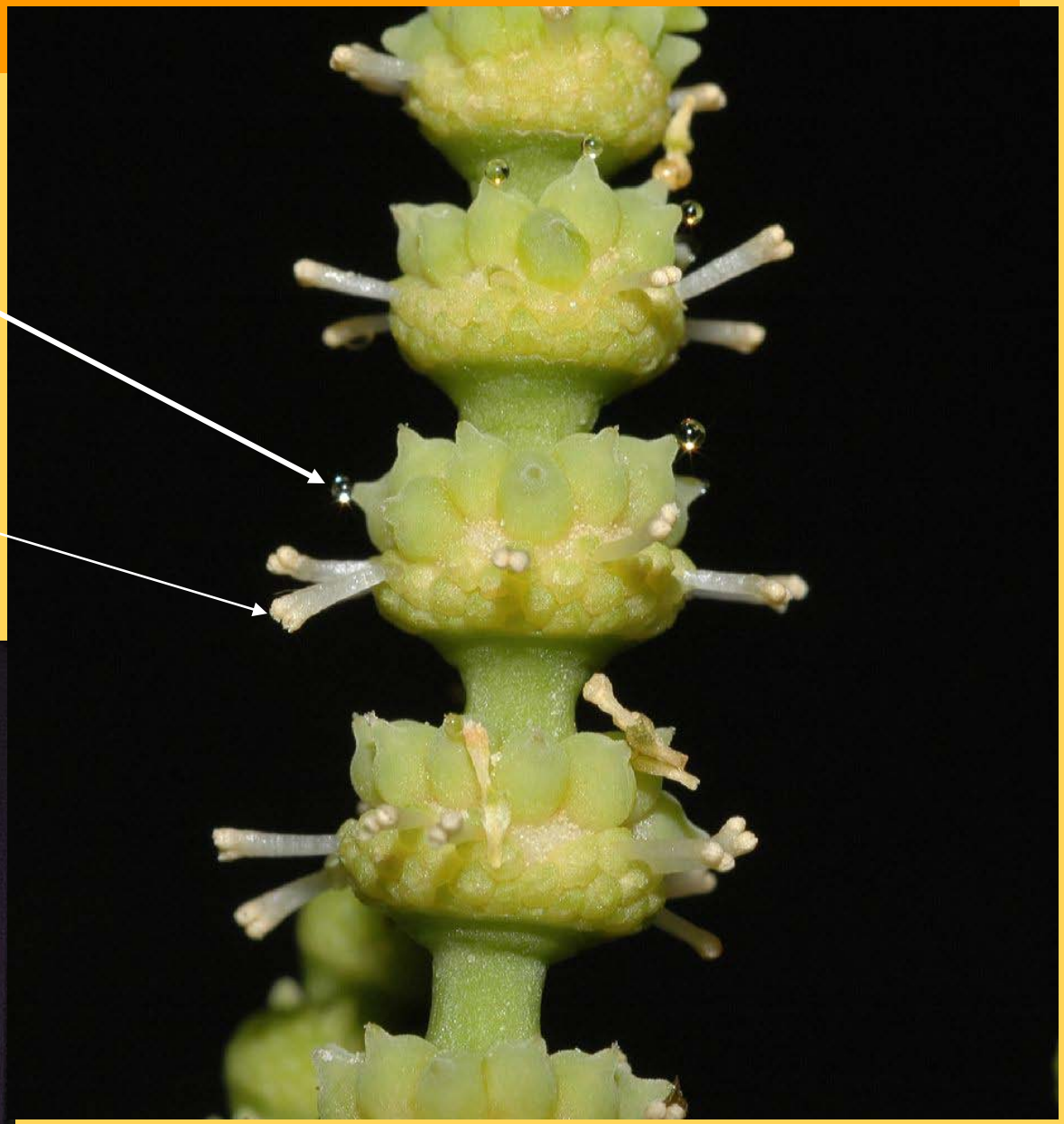
Gnetum

Gnetaceae – *Gnetum*

Gnetaceae – *Gnetum*

Flores femininas,
Óvulos com secreção
Apical na micrópila

Flores masculinas na base



Gnetales –*Ephedra*

Flor masculina

Gnetales –*Ephedra*

Megagametofito mineralizado

Nucela mineralizada do óvulo de uma “Antófita Gnetaleana”, do Cretáceo, cujo tubo polínico acoplado possui características semelhantes ao do pólen de *Ephedra* (Krassilov)

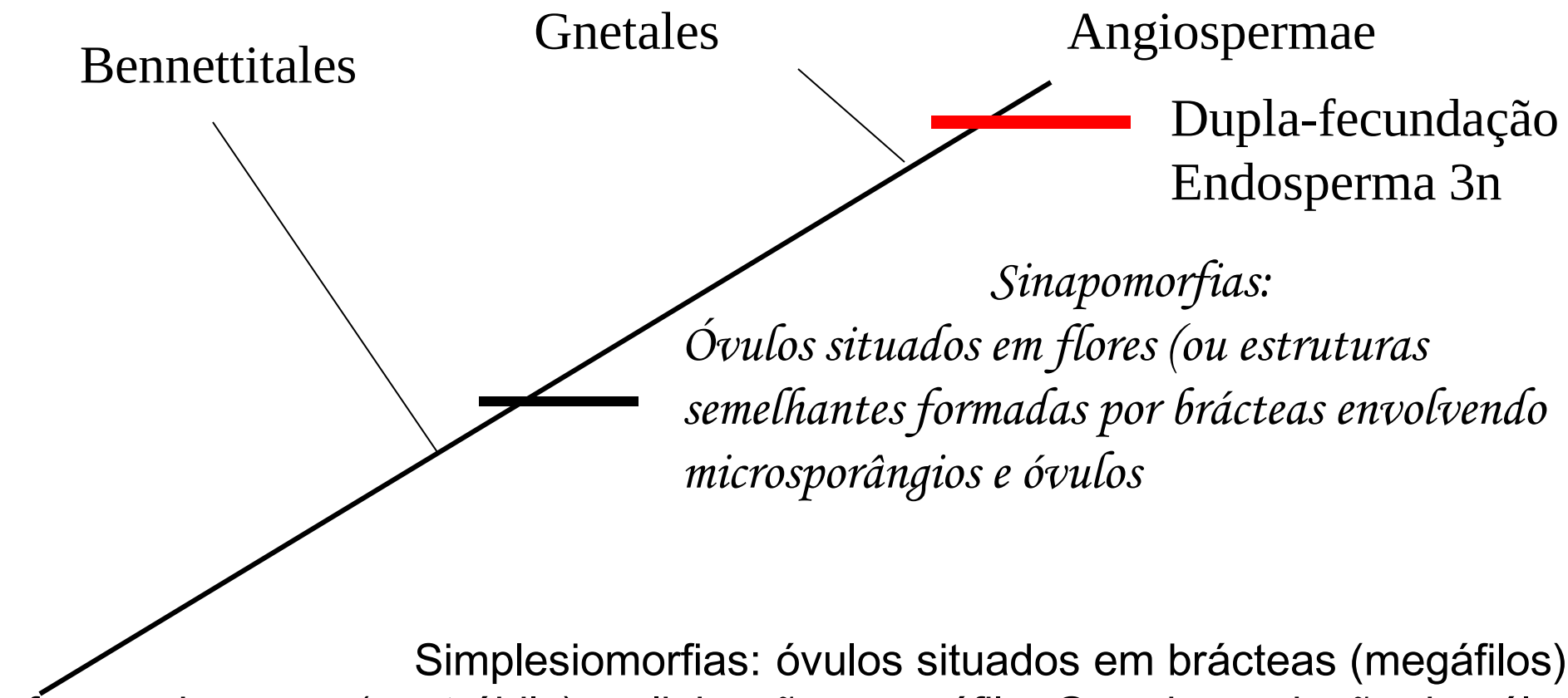
Gnetaceae

Ephedraceae

Welwitschia

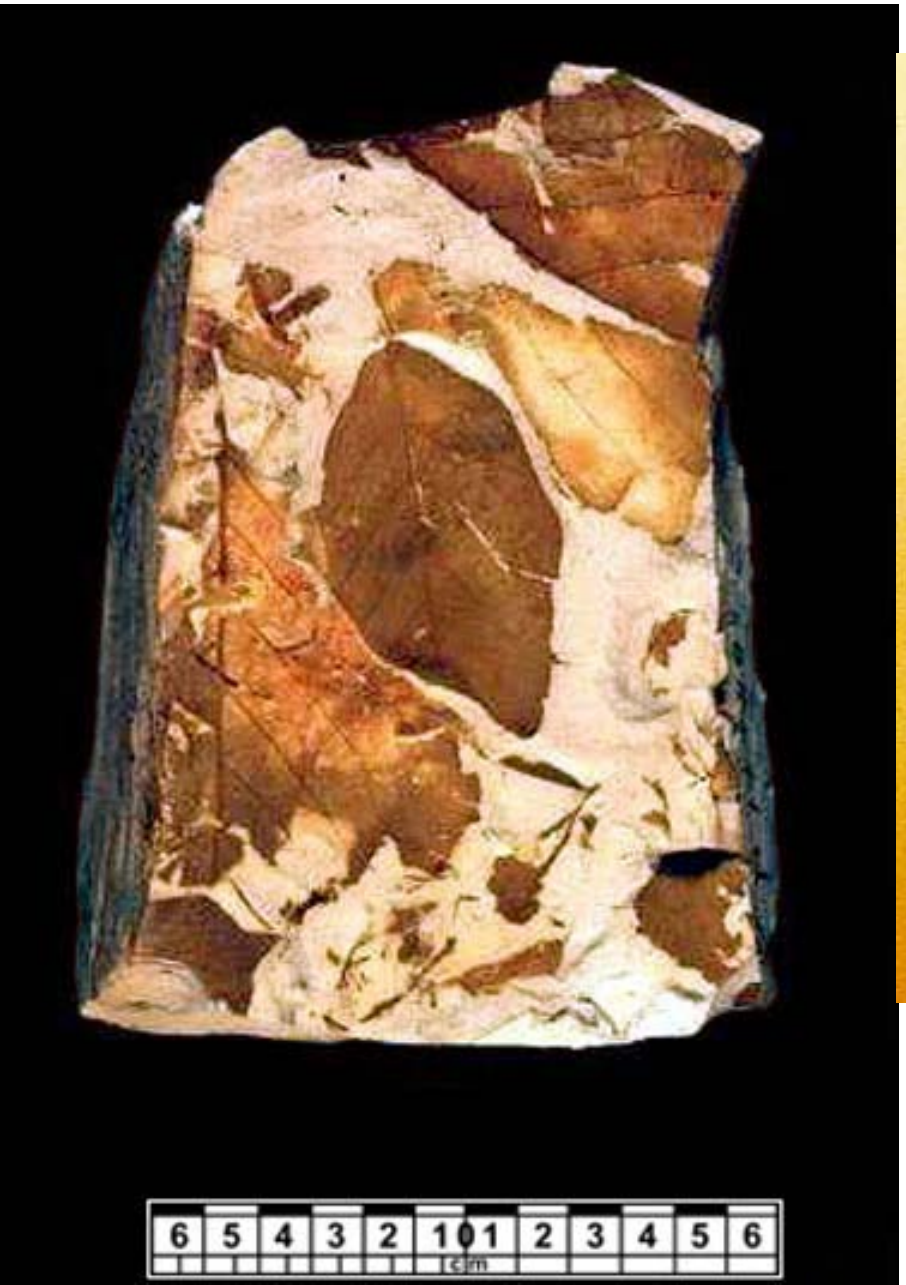
Origem a partir de uma morfoespécie de Gimnospermae

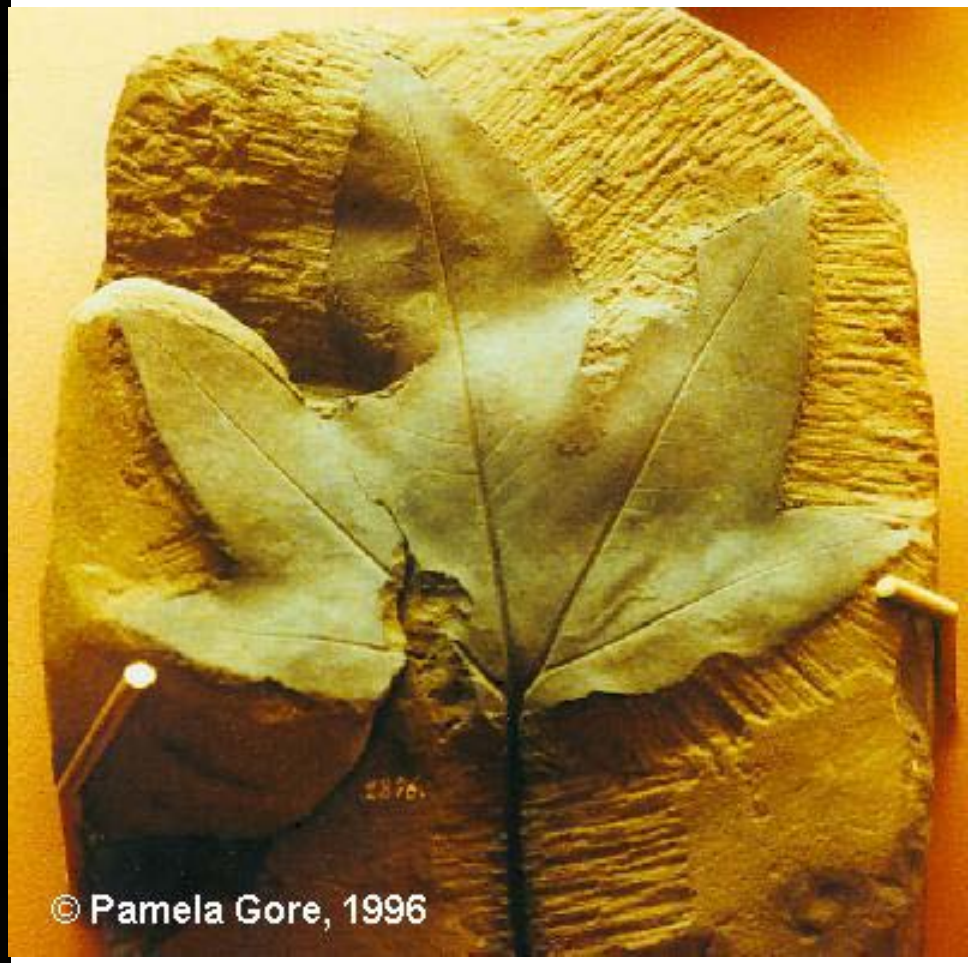
Antófitas (anto= flor funcional)



Simplesiomorfias: óvulos situados em brácteas (megáfilos), formando cones (=estróbilo), polinização anemófila. Grande produção de pólen
Pelos cones masculinos formados por micrófilos com microesporângios

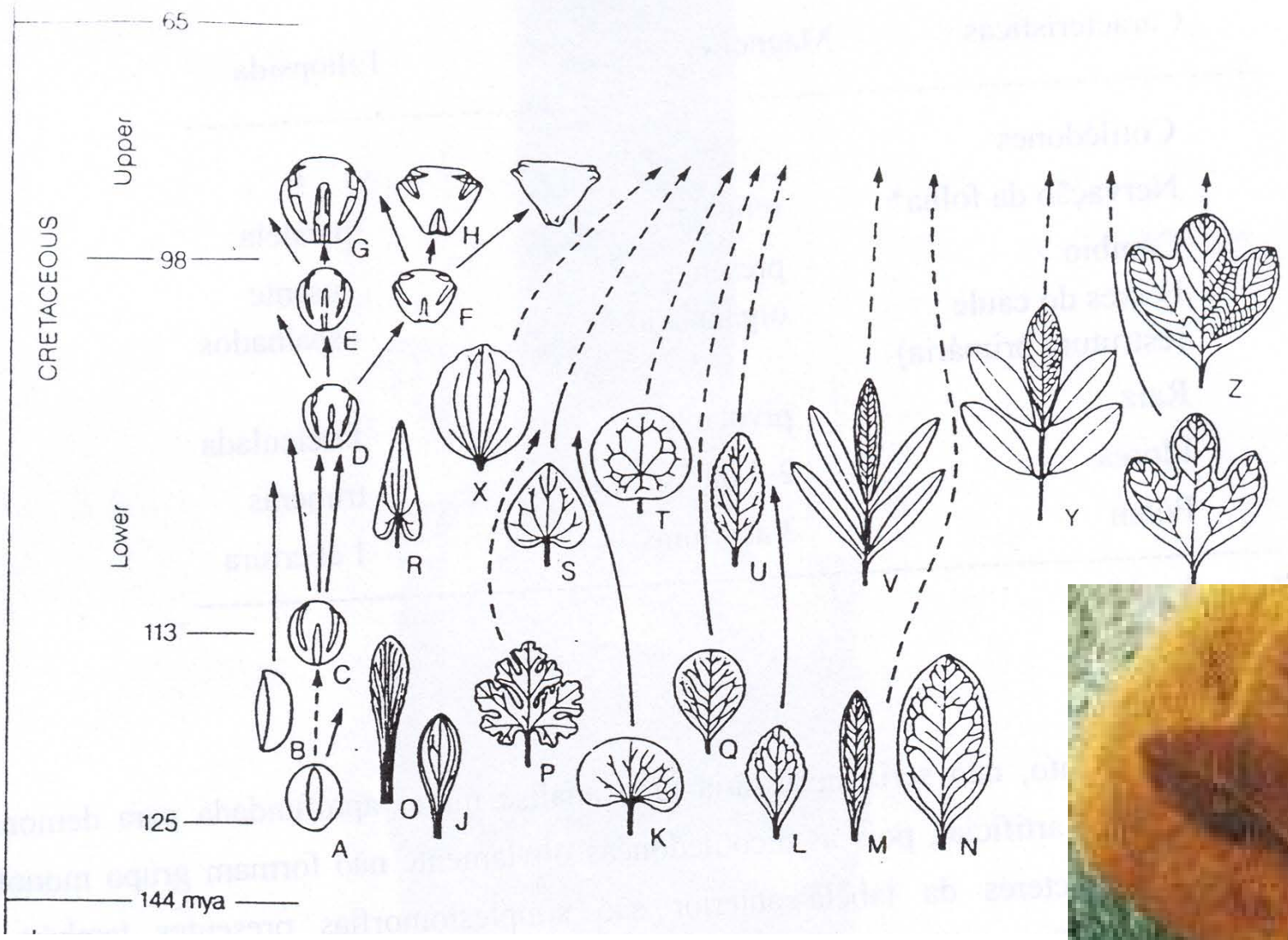
Folhas de Angiospermas do Cretáceo





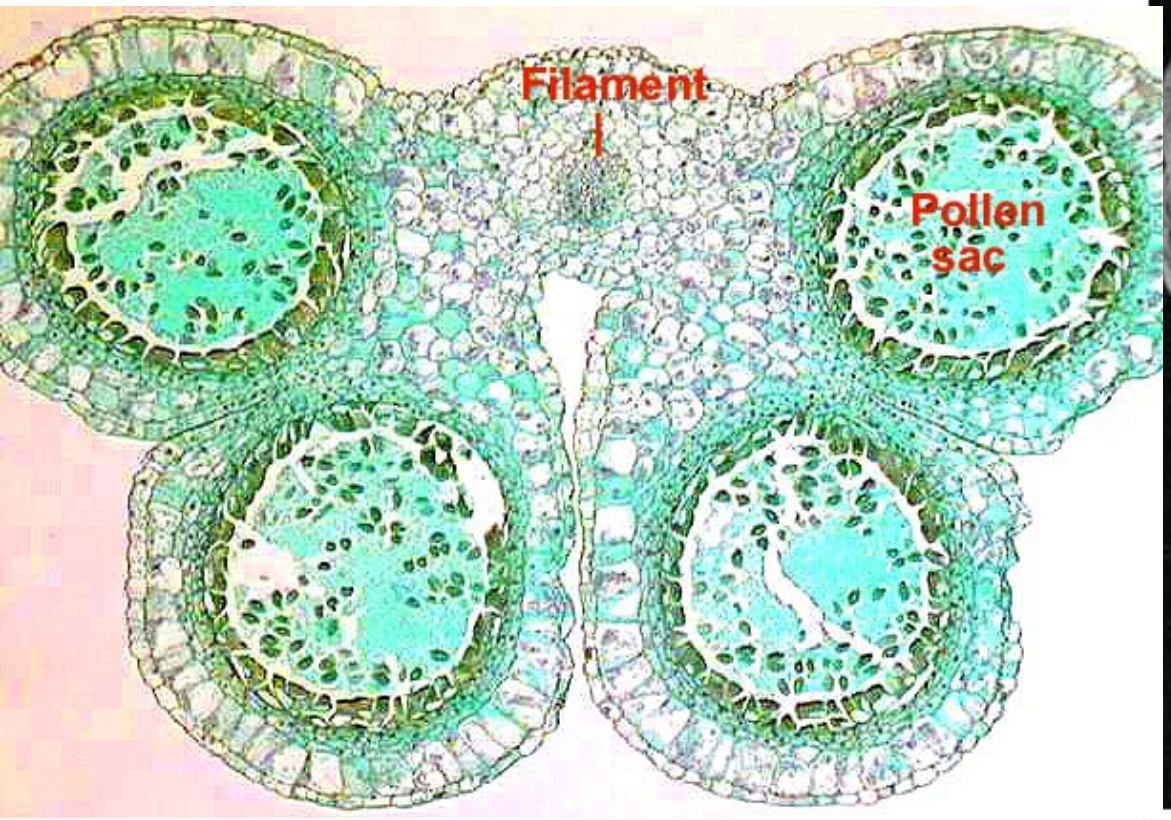
Folhas de Angiospermas do Cretáceo

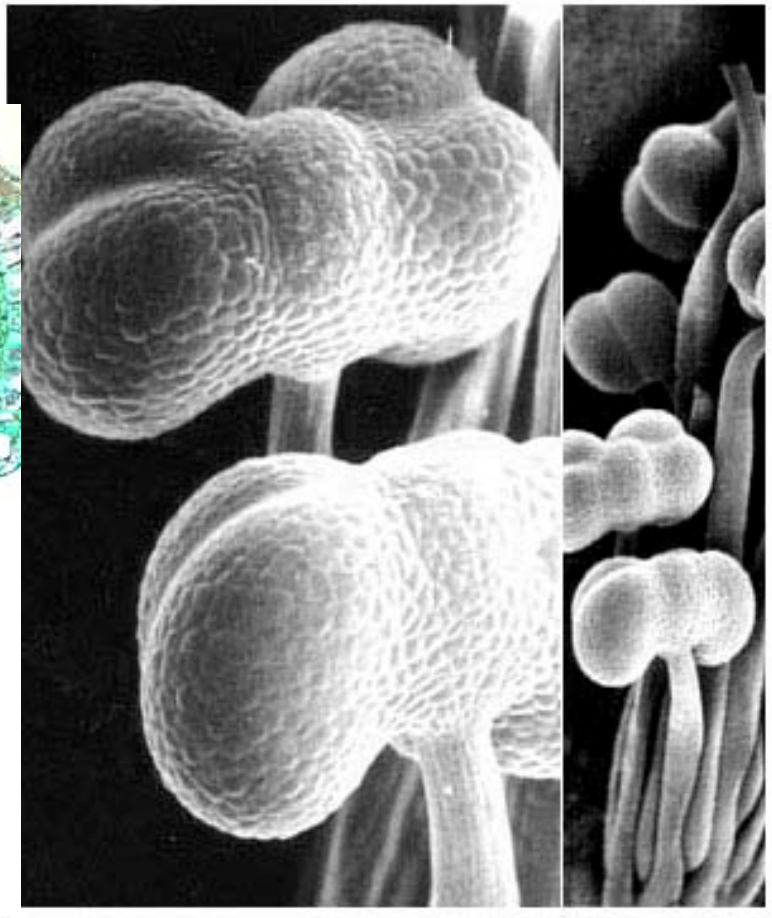
Registro fóssil de Angiospemas – Folhas e pólen



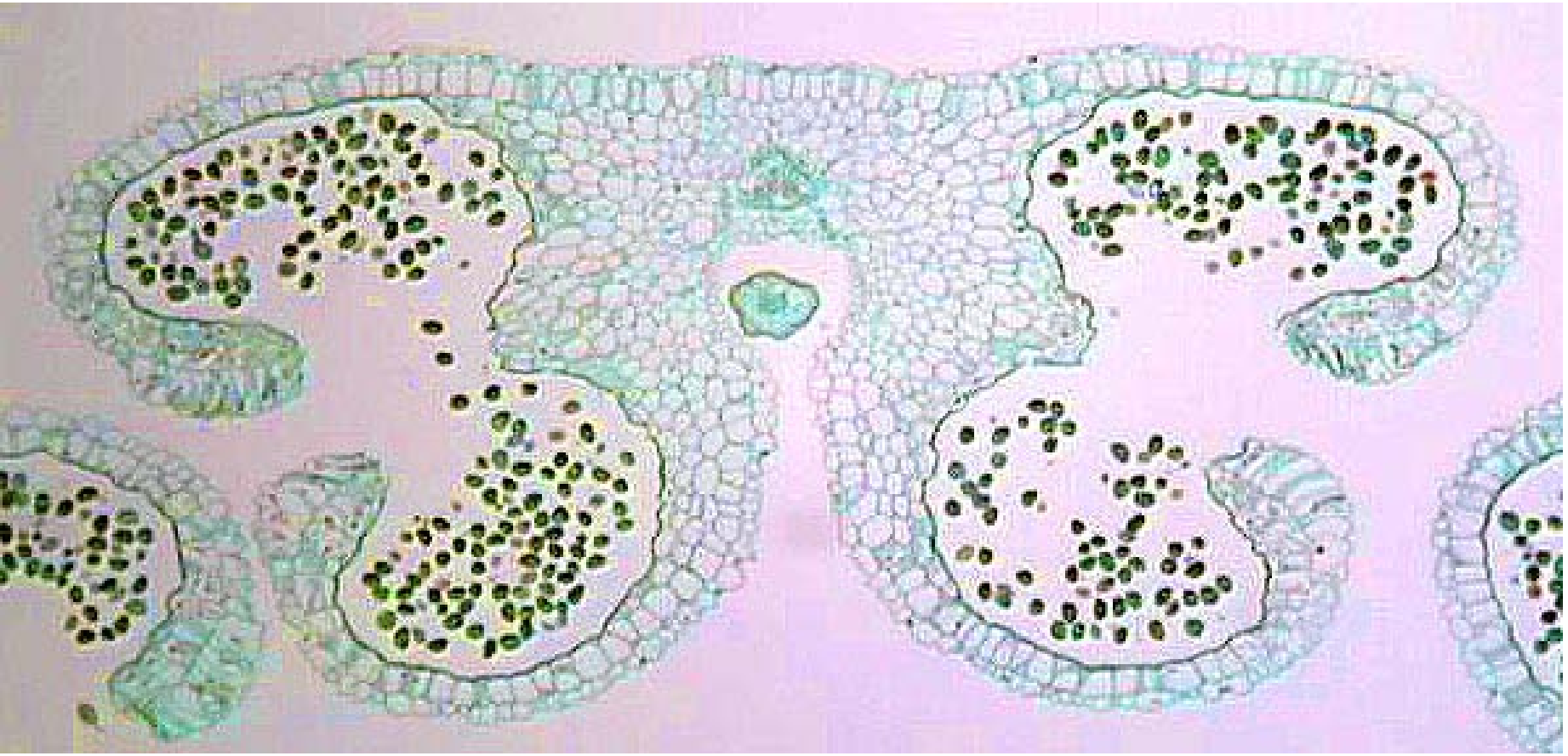
Produção de pólen em estruturas diferenciadas

Microesporângios ou sacos polínicos
produzem micrósporos (= grãos-de-pólen unicelulares), envolvidos pela Exina (esporopolenina) e pela intina (celulose e pectina).
Pares de microesporângios formam a teca, na antera.

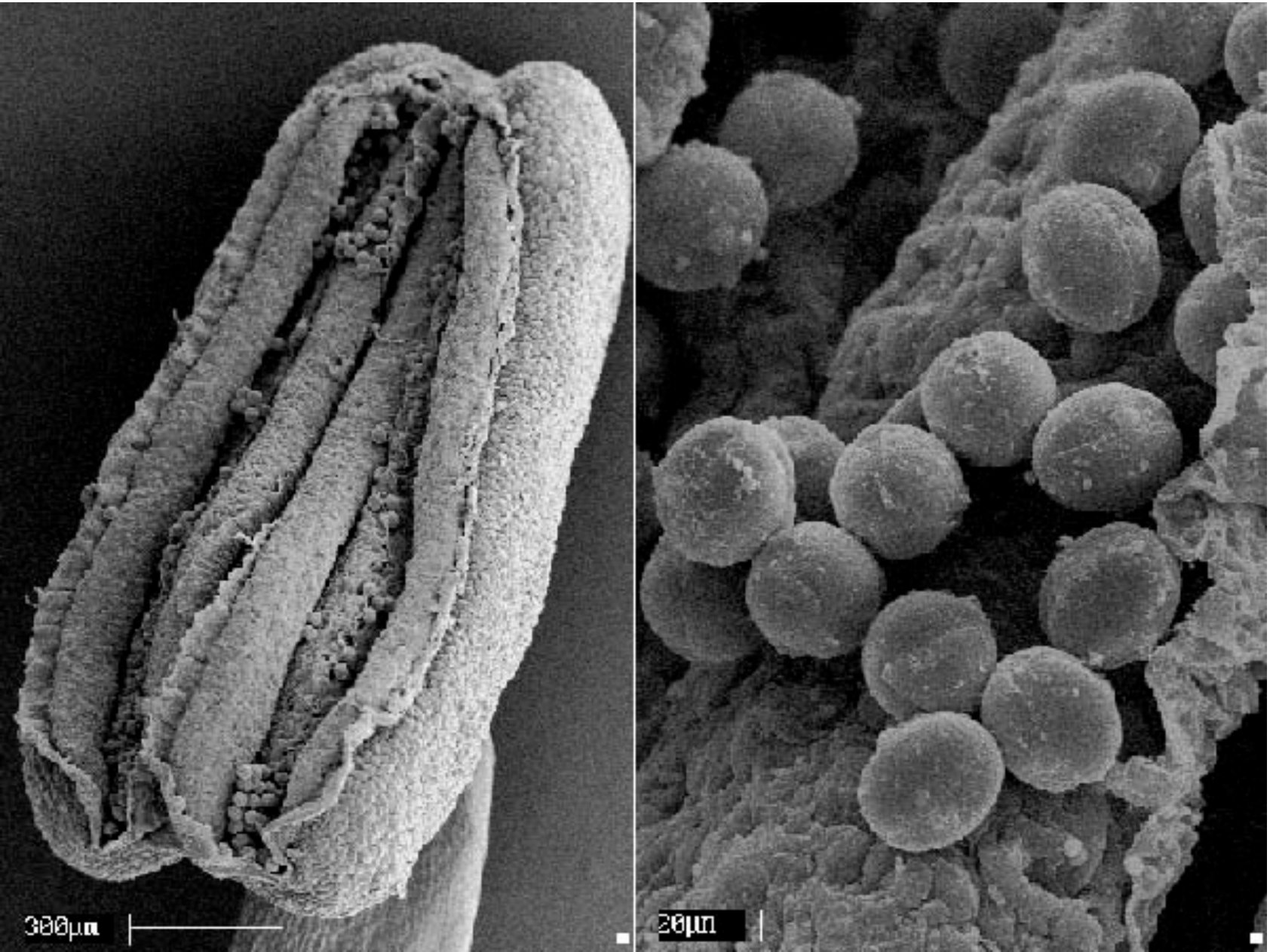




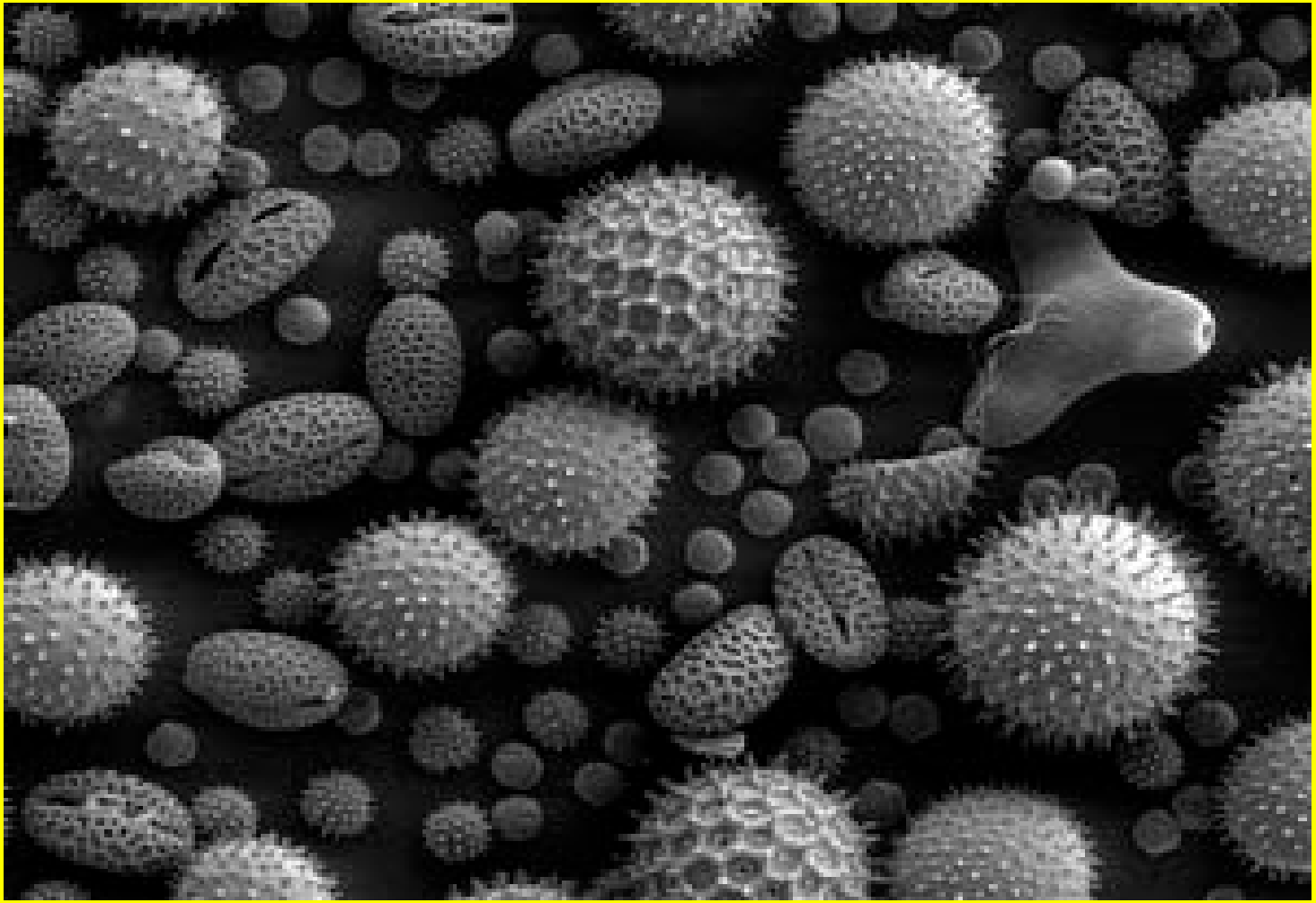
Deiscência das anteras



Angiospermae

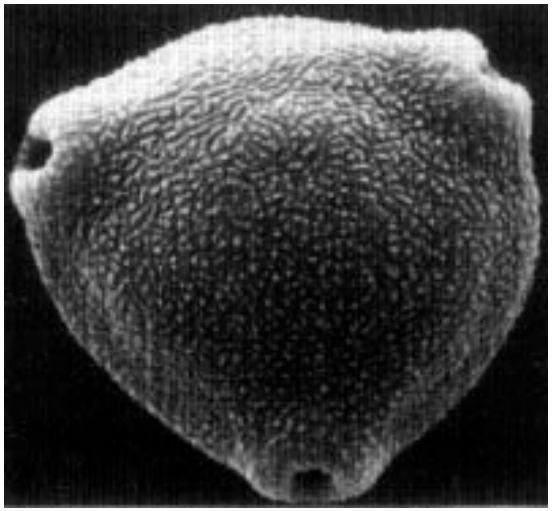


Forma do pólen e tipos de esculturas

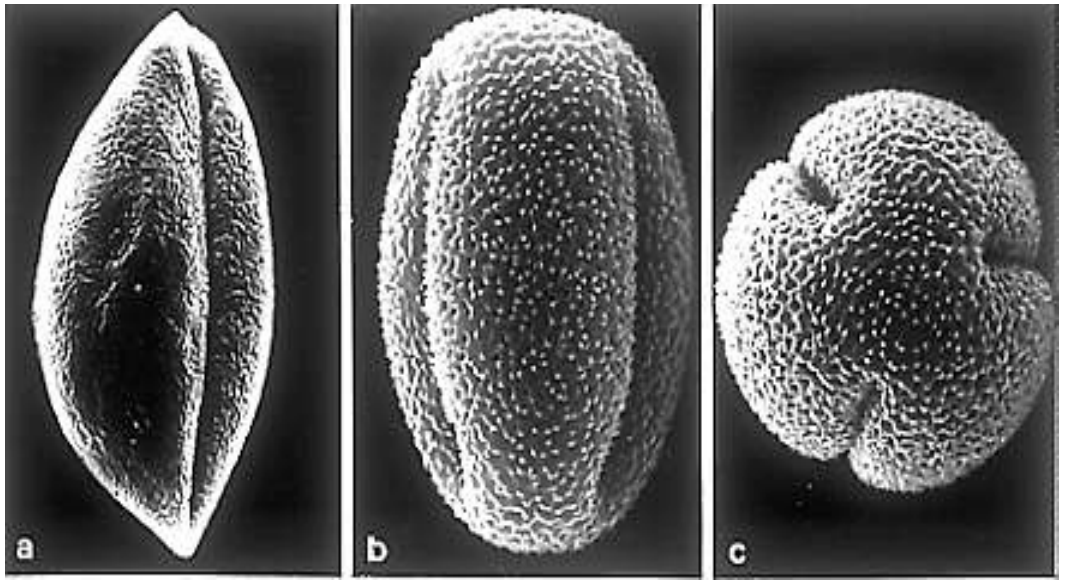


Forma do pólen e tipos de perfurações

Porados

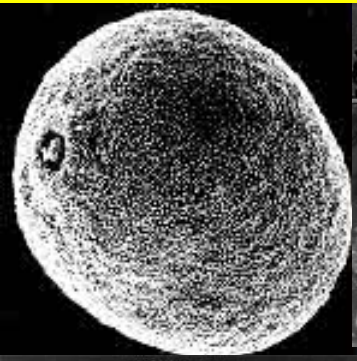


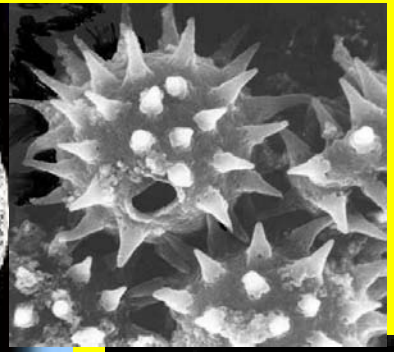
Colporados

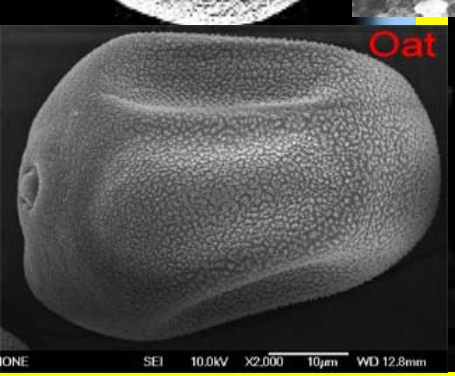


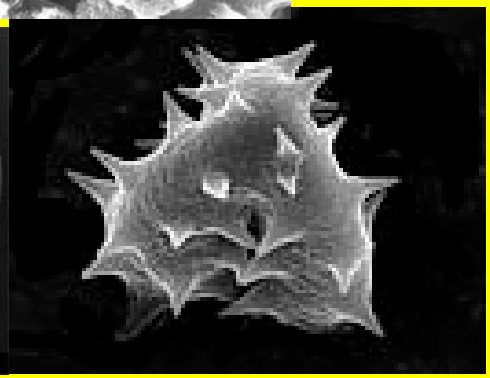
Colpados

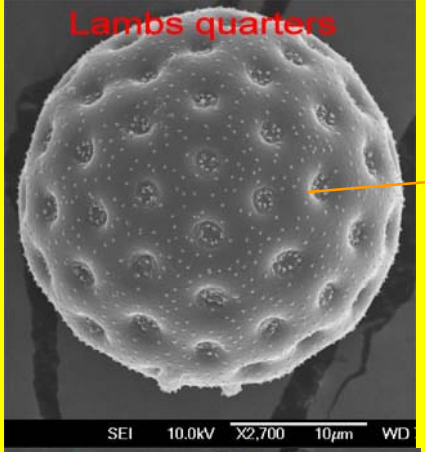
Porados

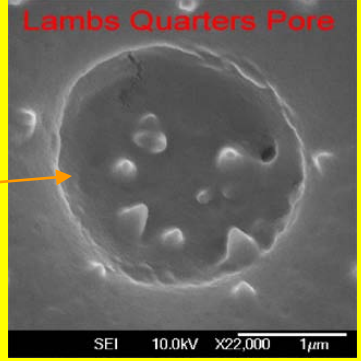


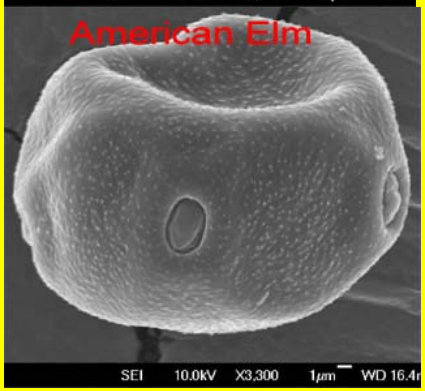


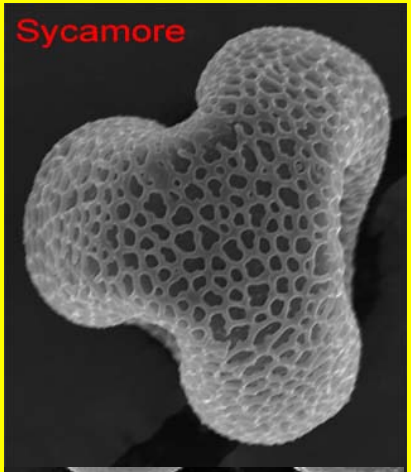


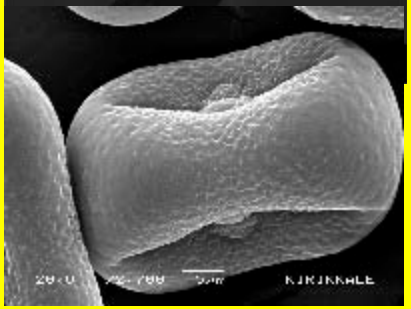






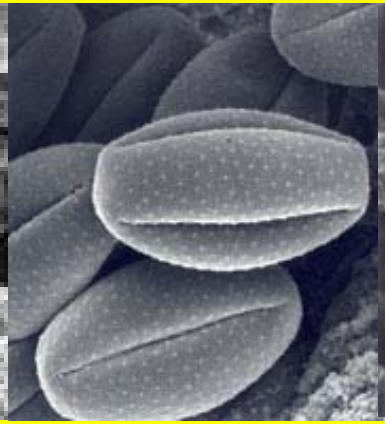




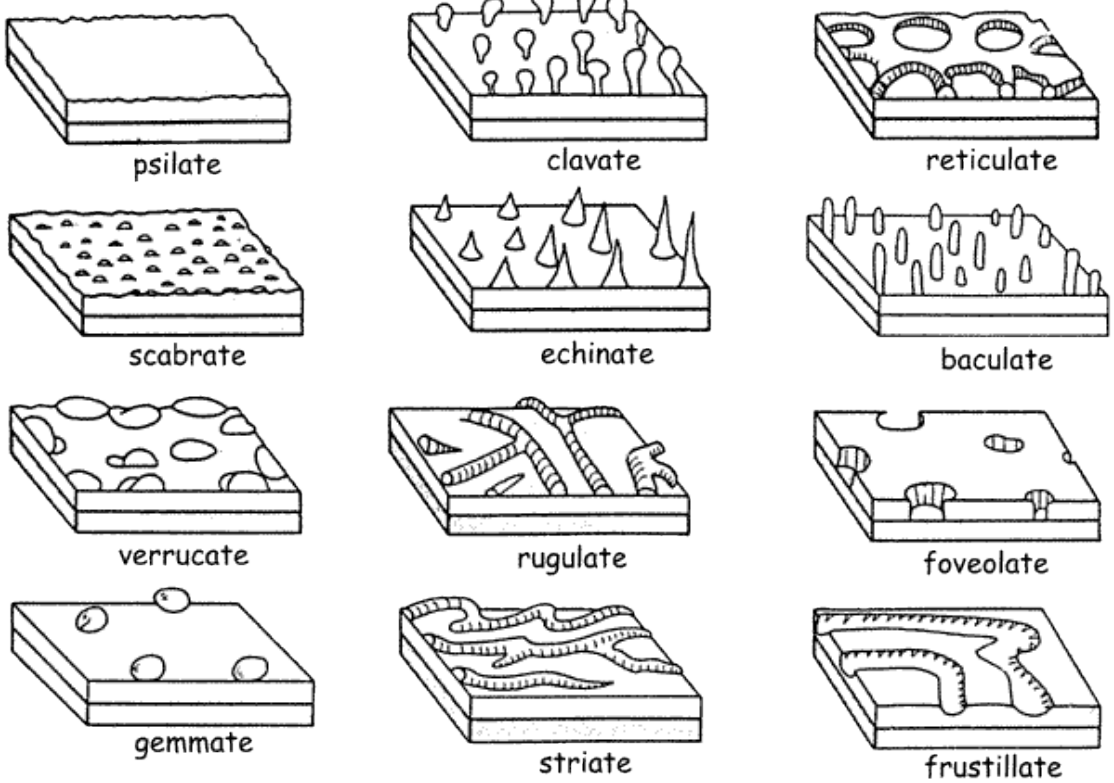


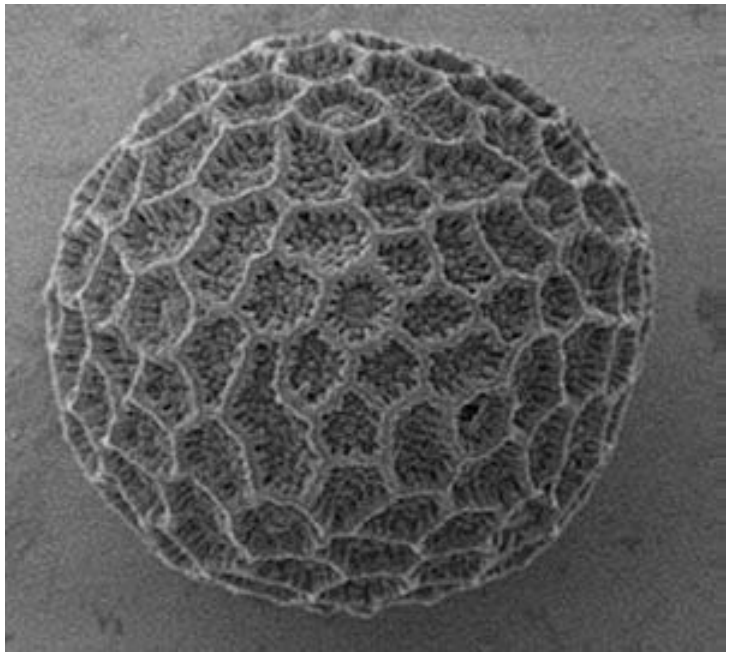
Colporados

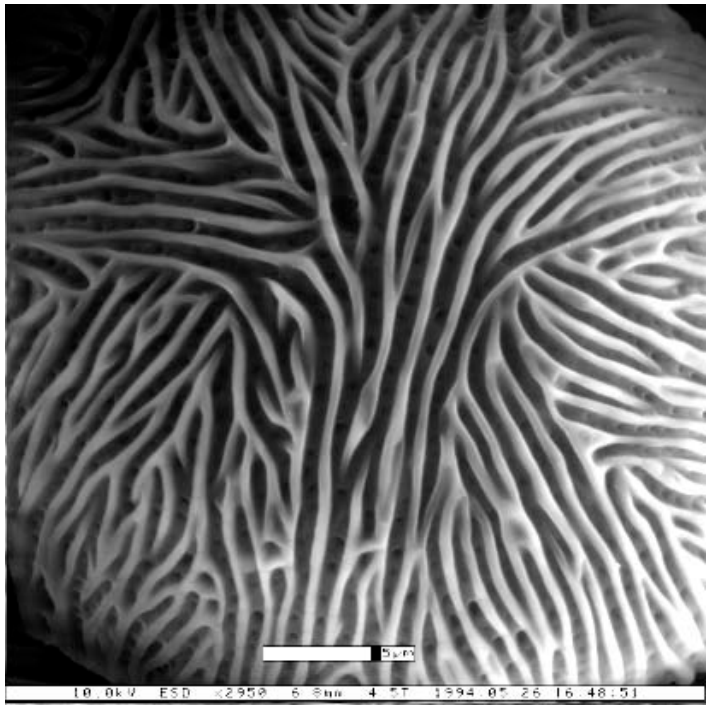
Colpados



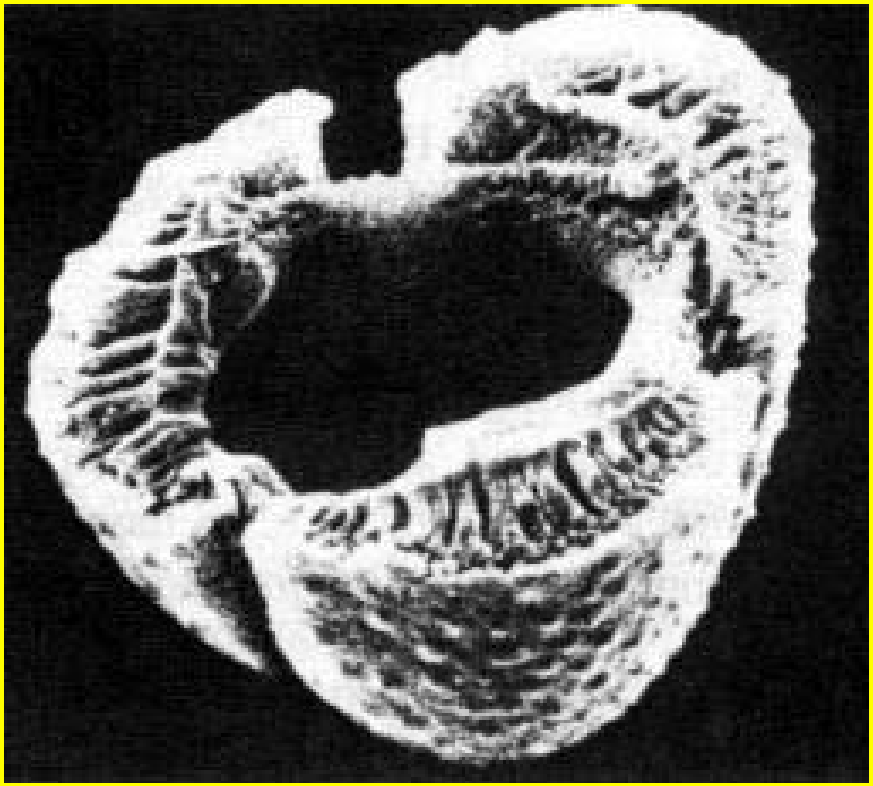
Tipos de superfície polínica







Tendências evolutivas - Pólen

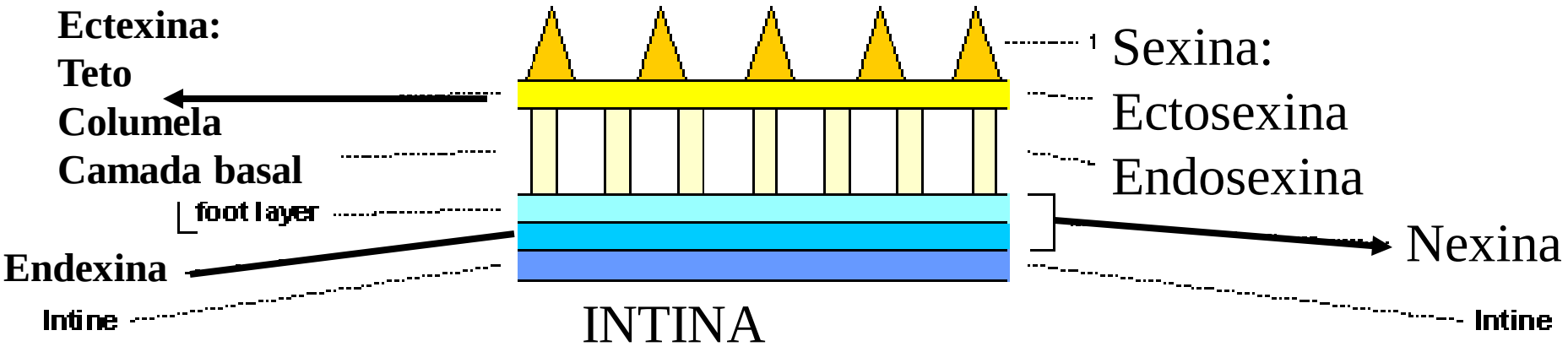


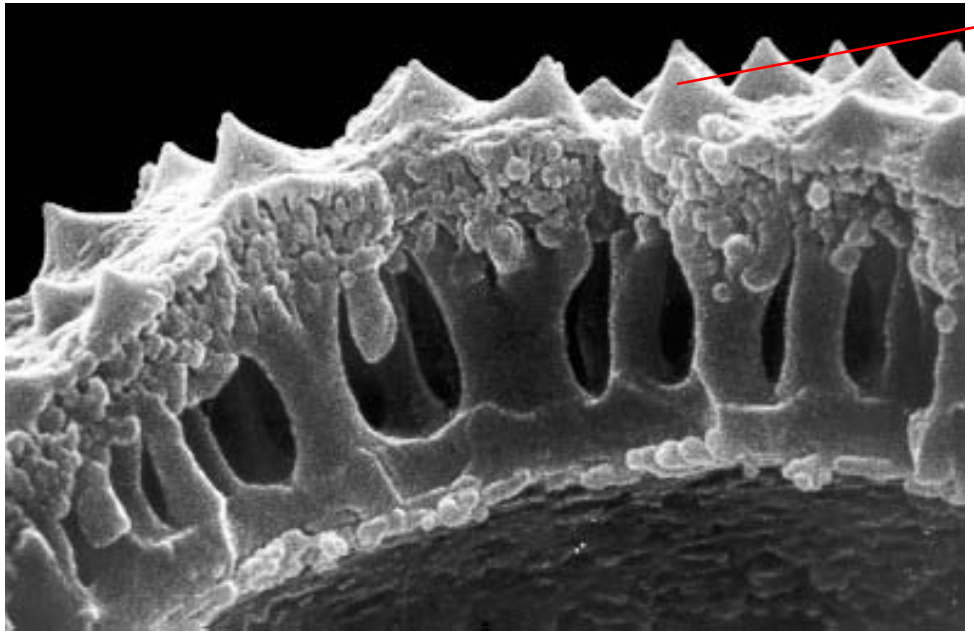
Exina columelada

Estrutura do pólen - Angiospermae

Fraegri 1966

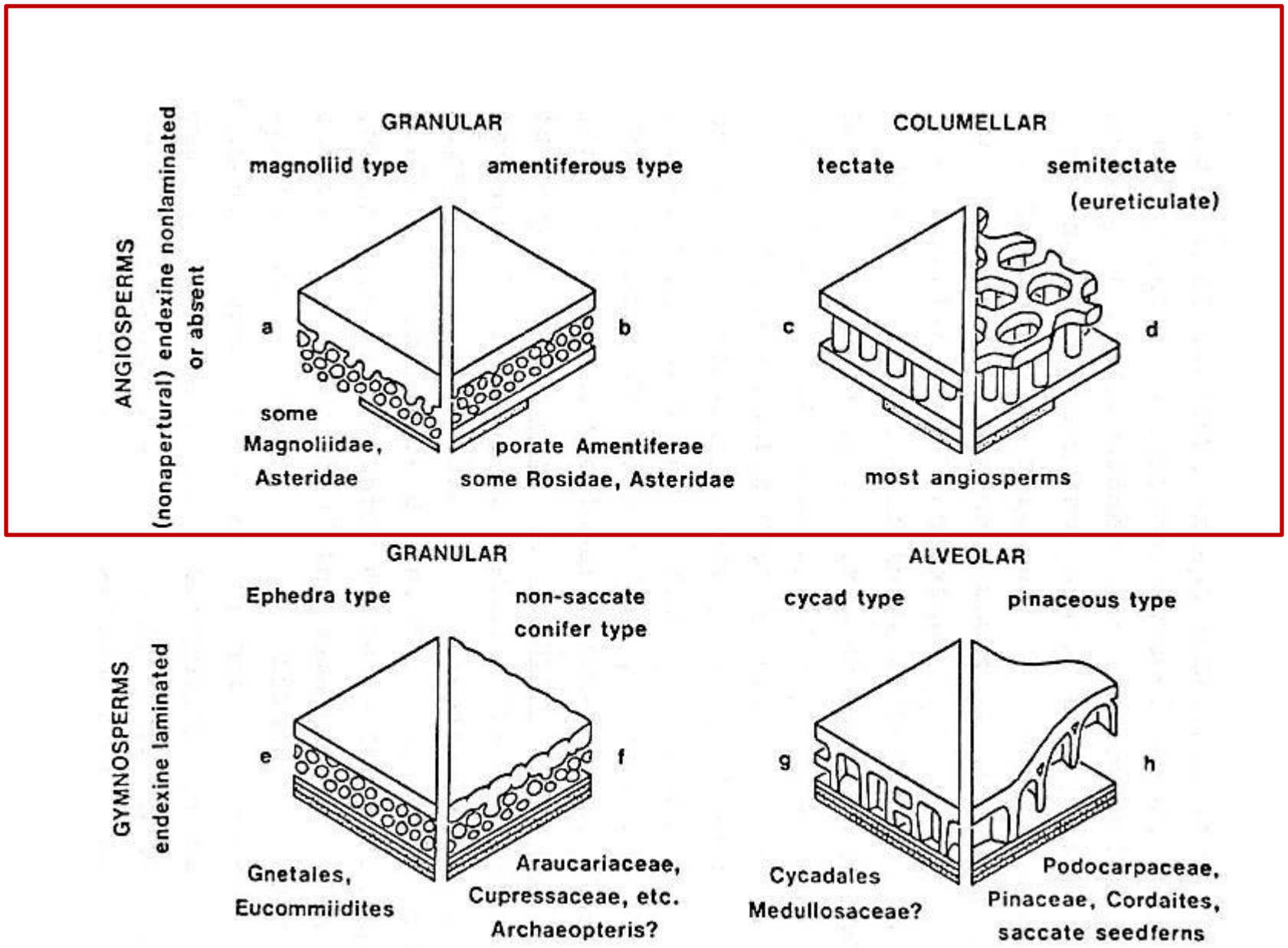
Erdtman 1966





Elementos tectais ou esculturas

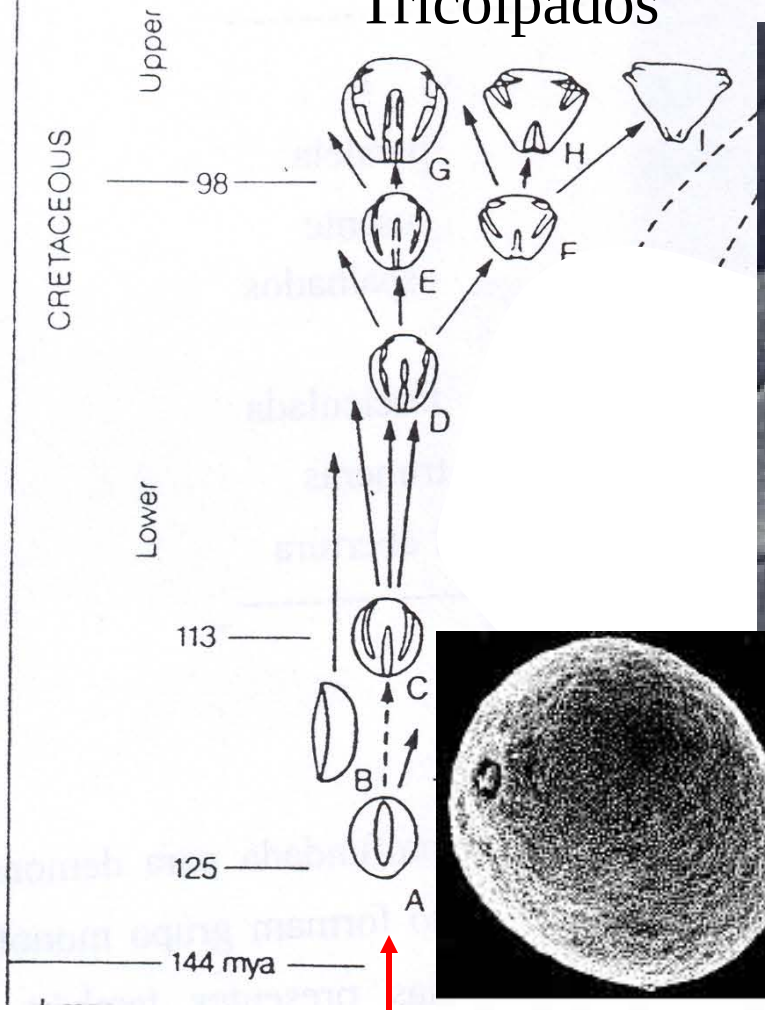
Exina estratificada

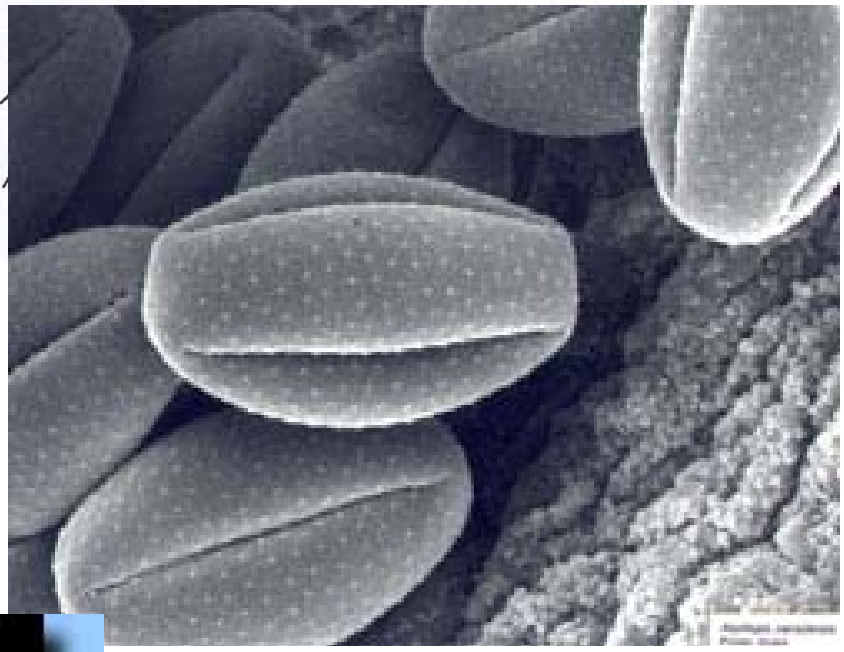

ANGIOSPERMS
(nonapertural) endexine nonlaminated or absent
GRANULAR
magnoliid type
amentiferous type
a
b
some Magnoliidae, Asteridae
porate Amentiferae
some Rosidae, Asteridae
COLUMELLAR
tectate
semitectate (eureticulate)
c
d
most angiosperms
GYMNOSPERMS
endexine laminated
GRANULAR
Ephedra type
non-saccate conifer type
e
f
Gnetales, Eucommiidites
Araucariaceae, Cupressaceae, etc. Archaeopteris?
ALVEOLAR
cycad type
pinaceous type
g
h
Cycadales Medullosaceae?
Podocarpaceae, Pinaceae, Cordaites, saccate seedferns

Doyle (1978)

Registro fóssil de Angiospemas

Tricolpados





Surgimento da flor

Ho: Pseudantial

Gnetophyta
Gnetales
Gnetum

Chlorantaceae

Sistema de Engler

Ho: Pseudantial

Piperaceae

Gnetophyta
Gnetales
Gnetum

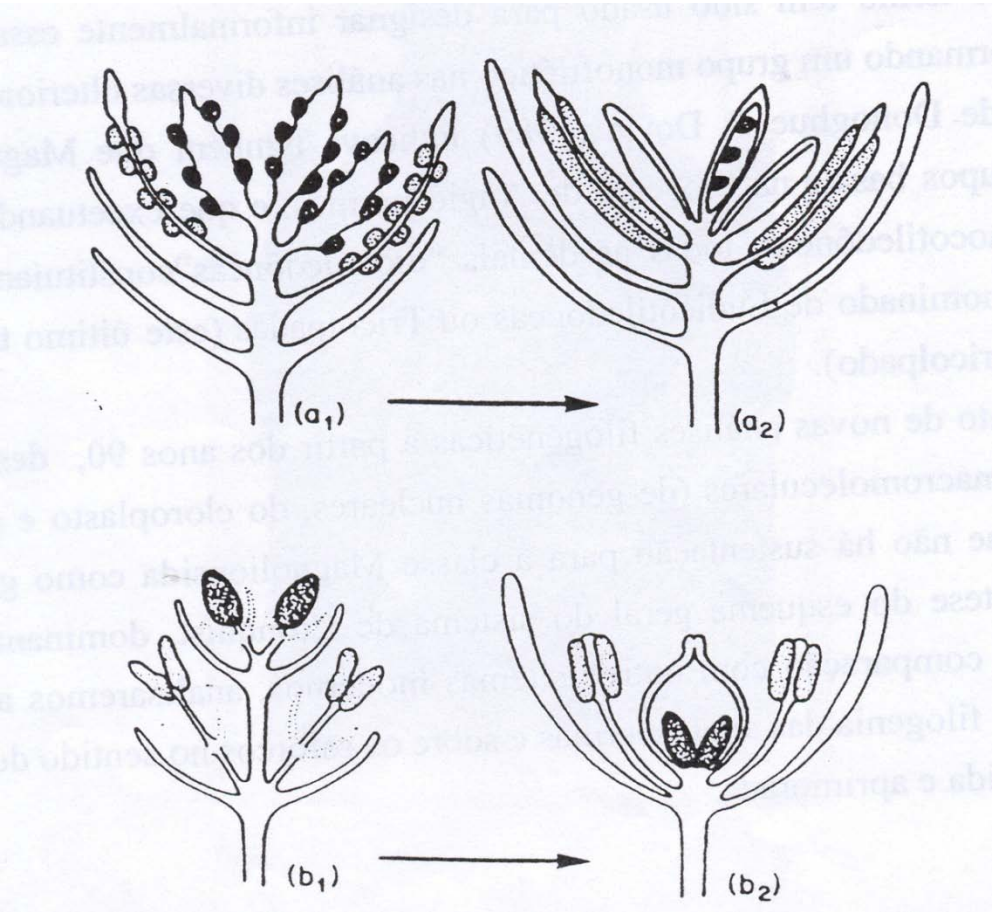
Bráctea peltada

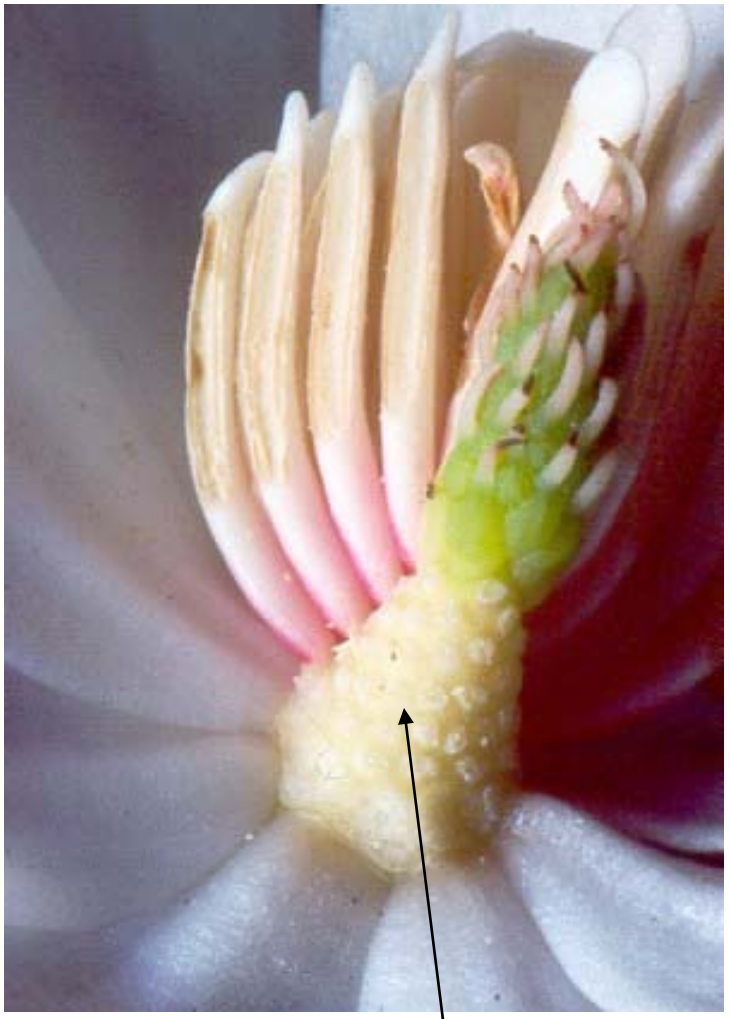
Estigma

Antera

Sistema de Engler

Ho: Euantial





Receptáculo cônico

Sistemas de Cronquist (1998) e Takhtajan (1997)

Ho: Euantial

Receptáculo cônico

Magnoliaceae

Flores primitivas Angiospermae

Distribuição
Espiralada
Das peças
florais

Estames

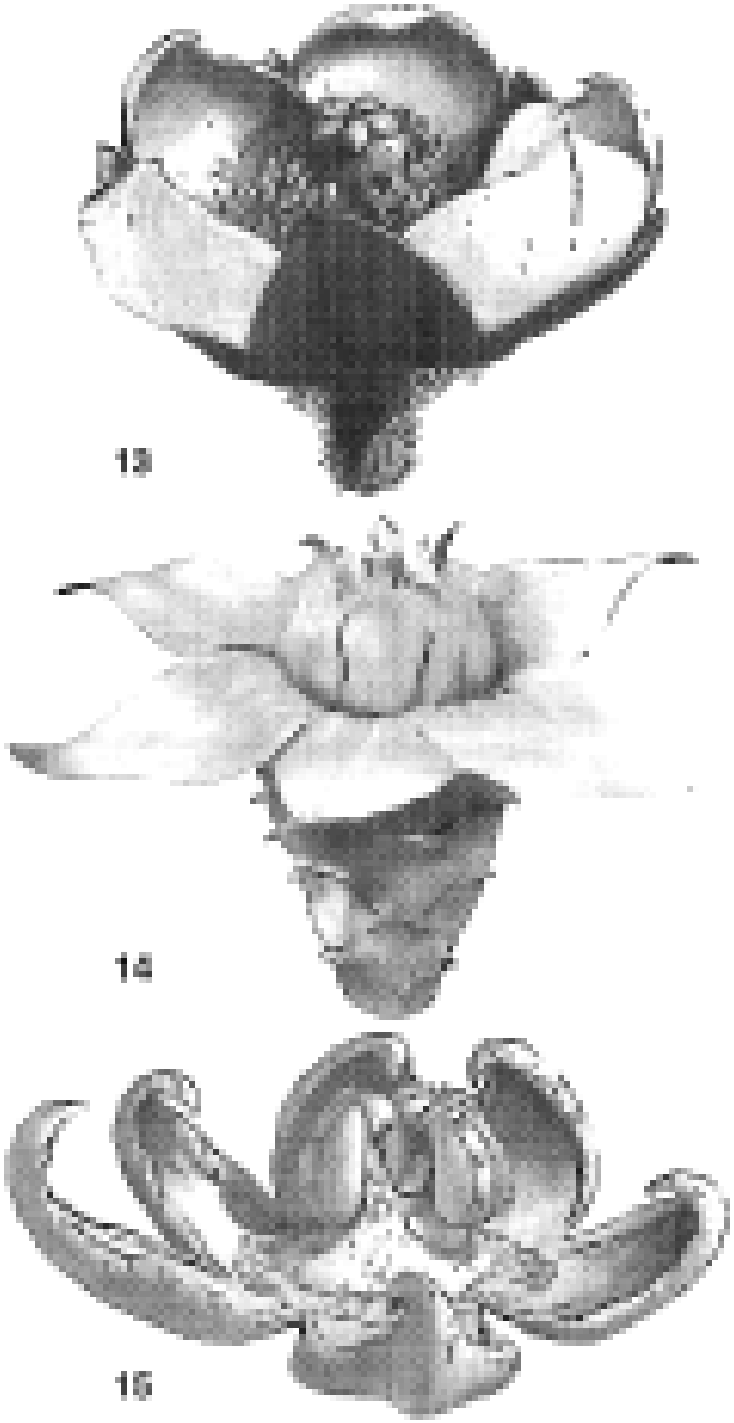
Receptáculo

Flores primitivas Angiospermae

Paleoclusia
Clusiaceae

Microvictoria
Nymphaeaceae

Mabelia
Monocot



Tépalas carnosas sobre receptáculo desenvolvido (cônico),
Verticilos em disposição espiralada,

Evolução floral das Angiospermas (Radford *et al.* 1974)

Flor amórfica, coripétala,
Triássico 230 m.a.

Flores radiais e haplomórficas,
(= estruturas simplificadas)
Cretáceo 130 m.a

Flor pleomórfica
(= estruturas diversificadas),
Cretáceo-Terciário 130-60 m.a

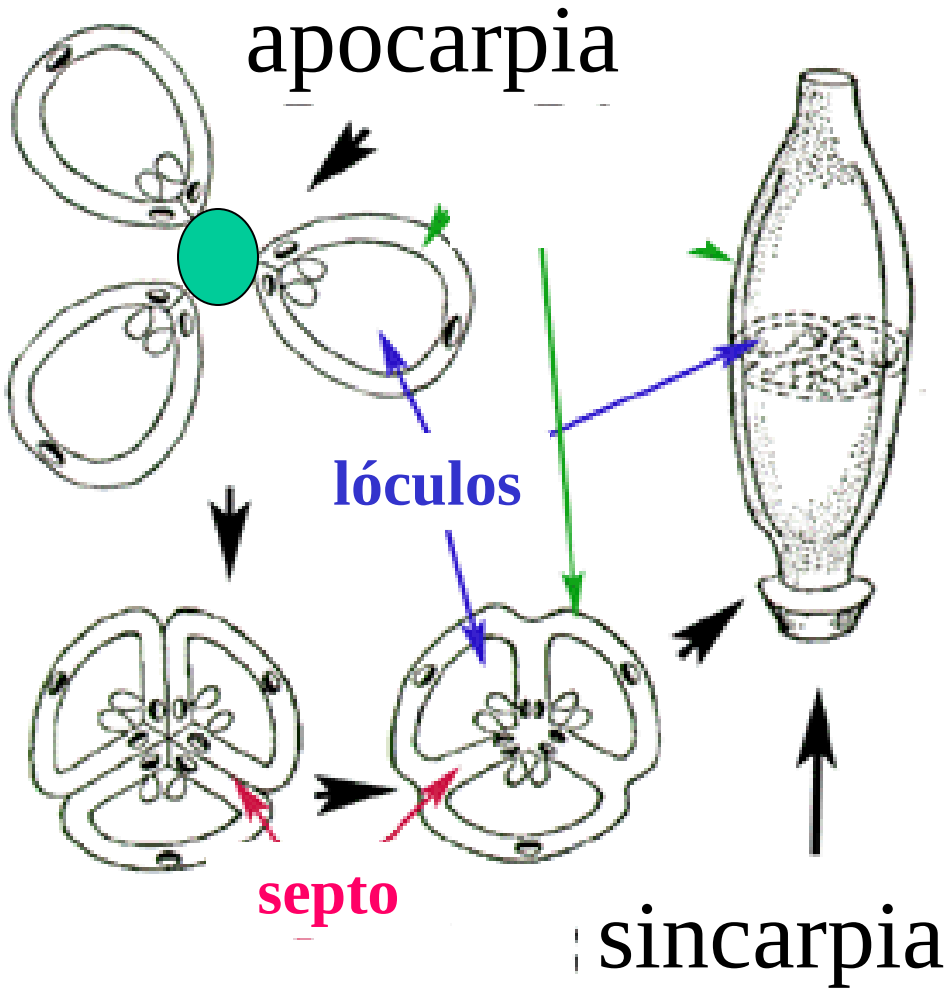
Flor simpétala, radial
Terciário 60 m.a.

Flor simpétala,
Bilateral
Terciário 60 m.a

Irradiação evolutiva

Plesiomorfia em flores de Angiospermae

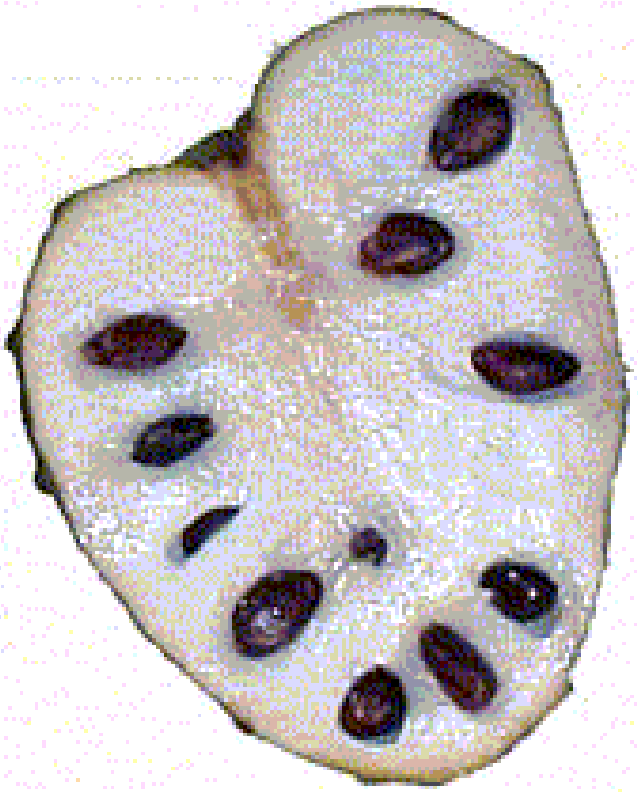
Ovário apocárpico evoluindo para ovário gamocárpico



Plesiomorfia em flores de Angiospermae

Ovário apocárpico fecundado, desenvolvendo frutos carnosos – bagas, as quais Juntam-se formando um fruto agregado

Uma única flor, desenvolvendo vários carpelos: fruto agregado de bagas.

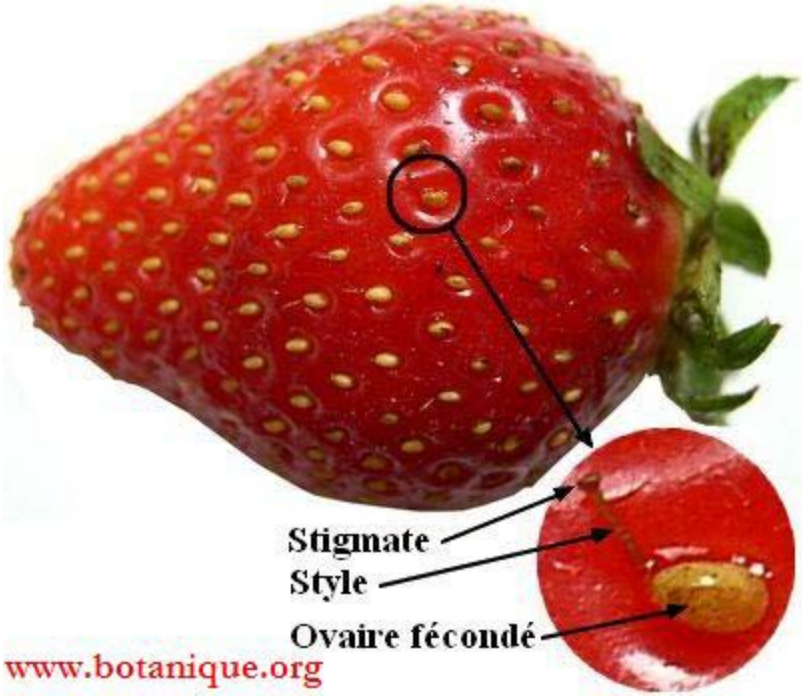


Plesiomorfia em flores de Angiospermae

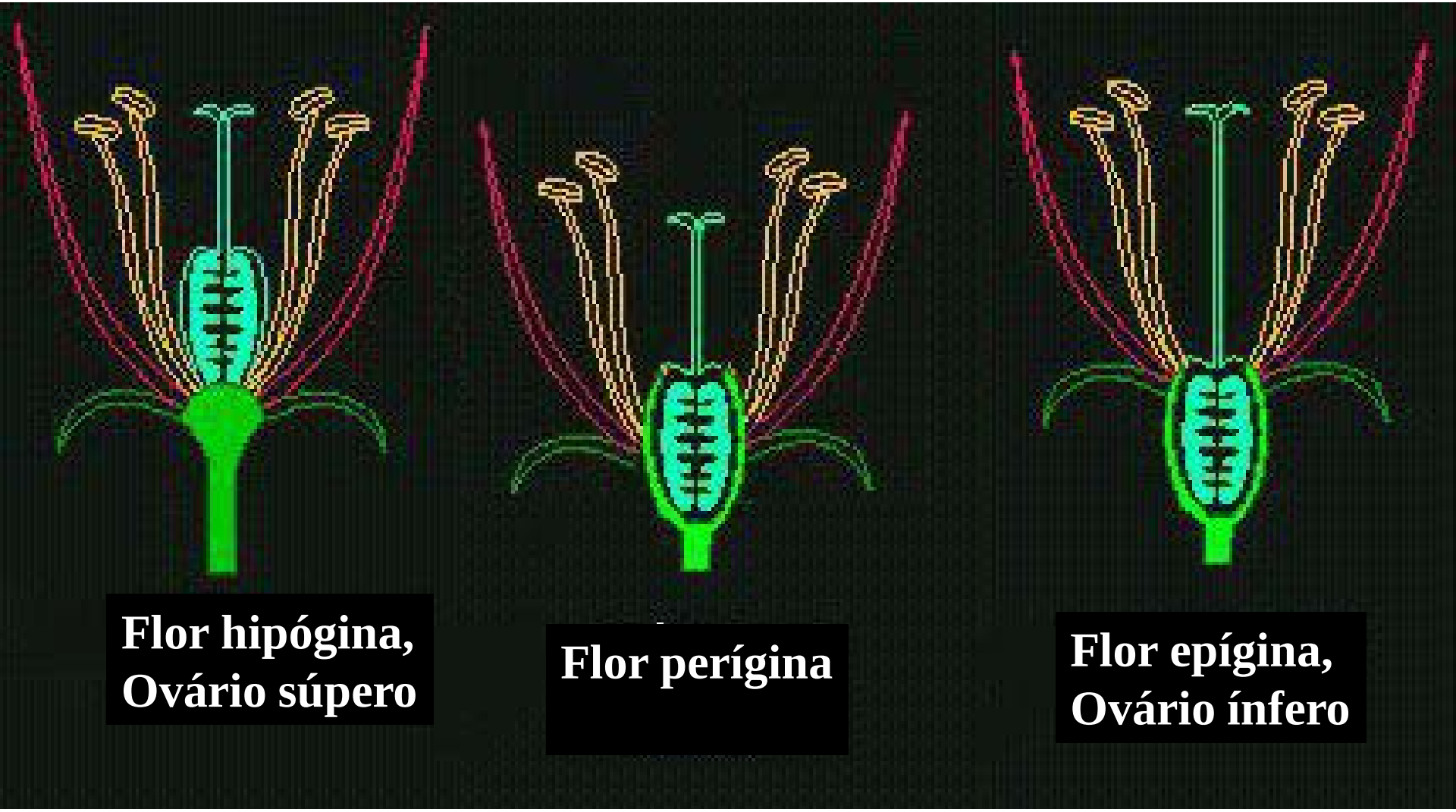
Fruto agregado de aquênios

Receptáculo

Fruto agregado de bagas



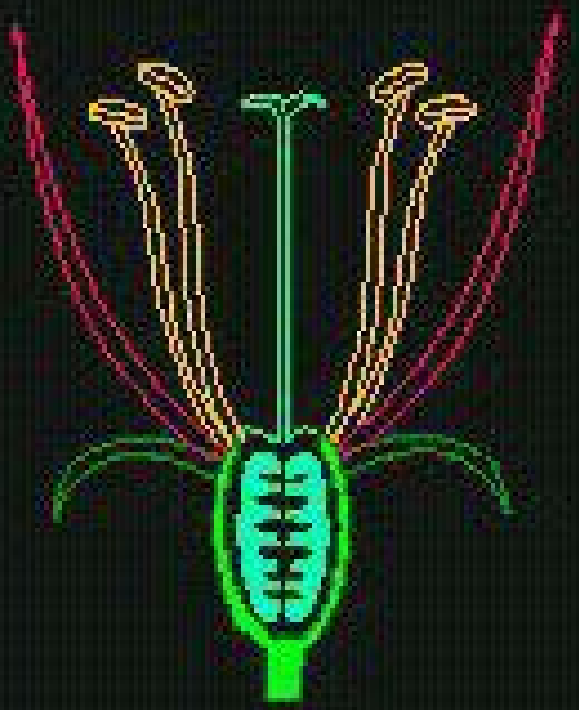
Perfil floral



Flor

perígena pela expansão do Receptáculo (ov. súpero)

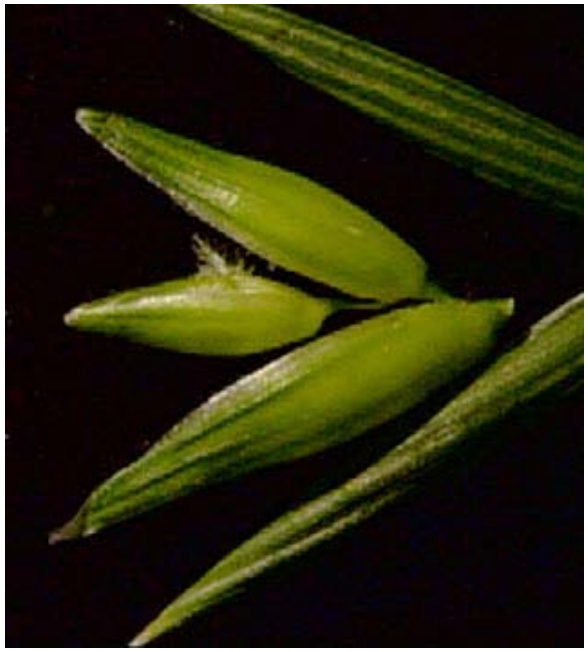
Perfil floral

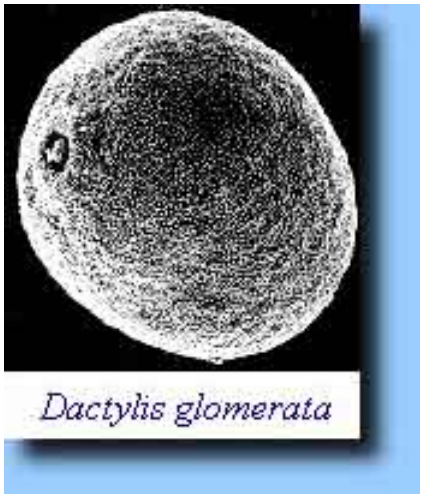


Flor epígina,
Ovário ínfero

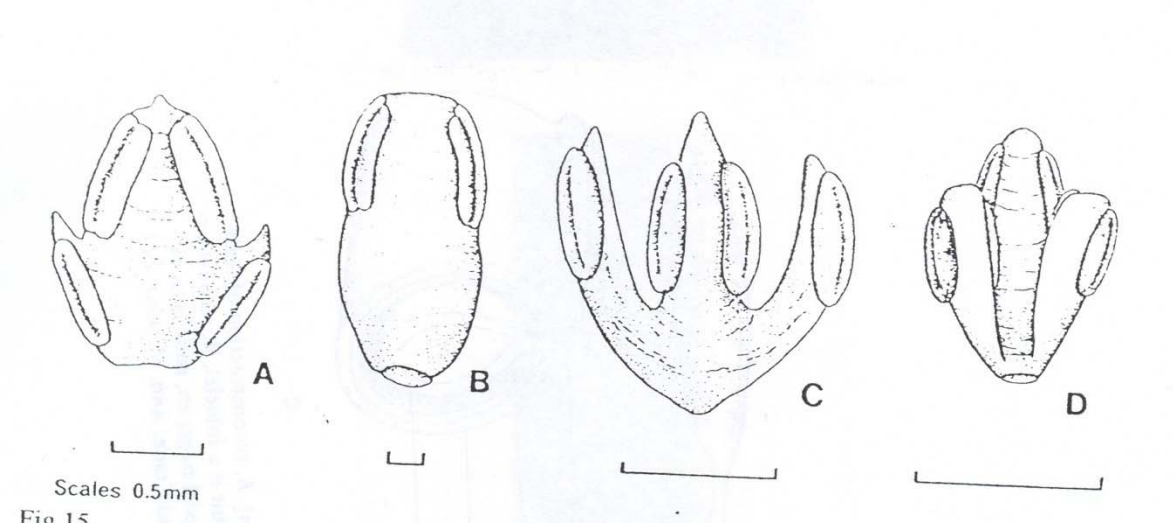
Receptáculo (hipanto) ao redor do ovário.

Tendências evolutivas - anemofilia





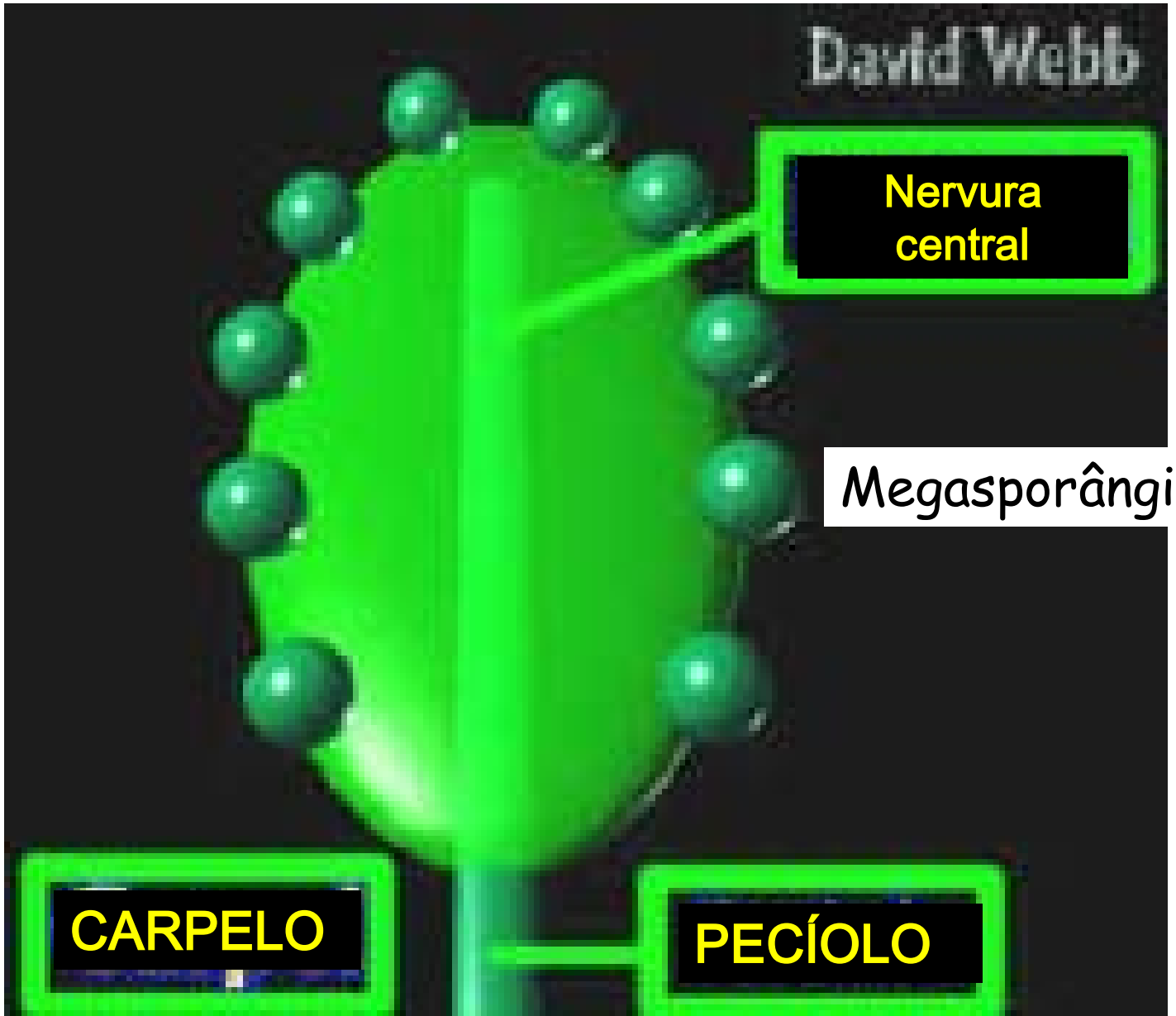
Evolução do Androceu



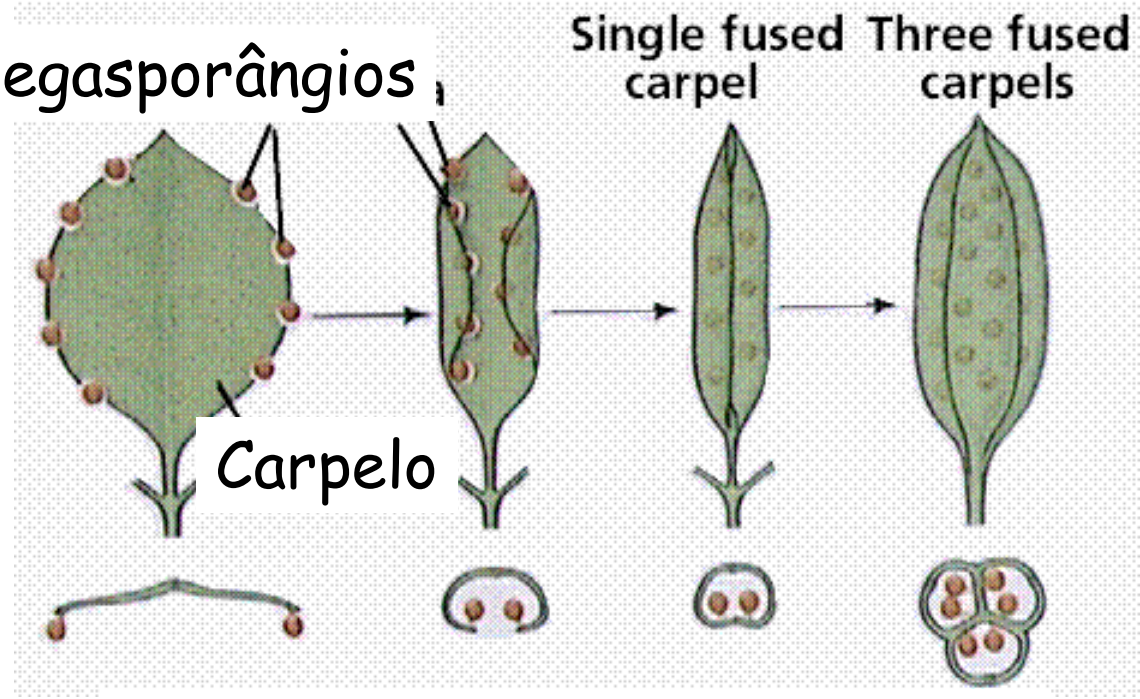
Estames com filetes não diferenciados em Chloranthaceae

Estames com filetes lineares, distinção filete-antera

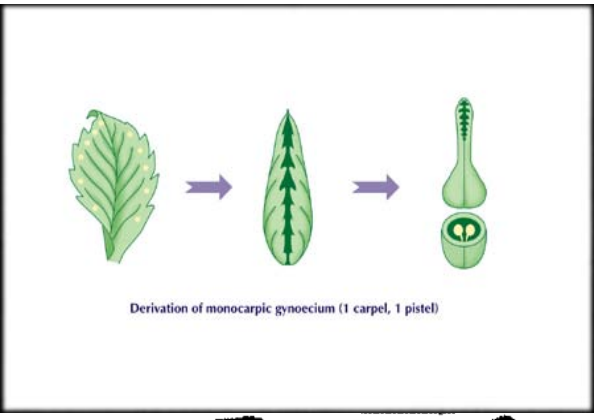
Tendências evolutivas - Gineceu

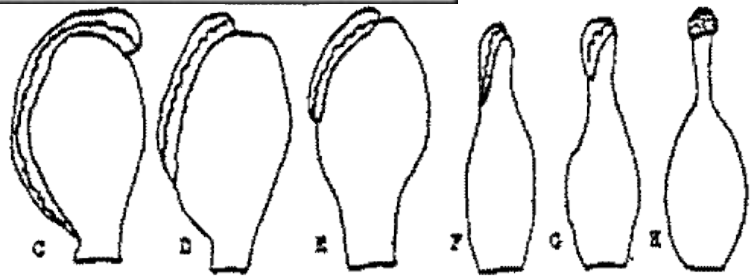


Tendências evolutivas - Gineceu



Carpelos conduplicados
(dobrados dorsi-ventralmente)

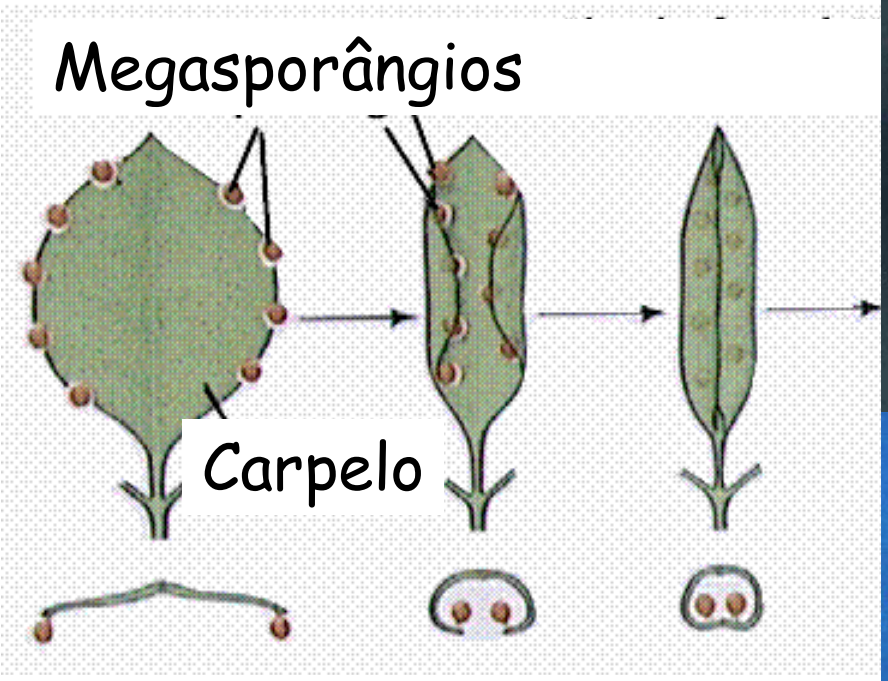




Tendências evolutivas - Gineceu

Ovário unicarpelar (independente do número de óvulos), **pacentação parietal** resultando num **fruto seco**, **Deiscente longitudinalmente** - **FOLÍCULO**

Deiscente longitudinalmente formando duas valvas – LEGUME



Carpelos conduplicados
(dobrados dorsi-ventralmente)

Folículo

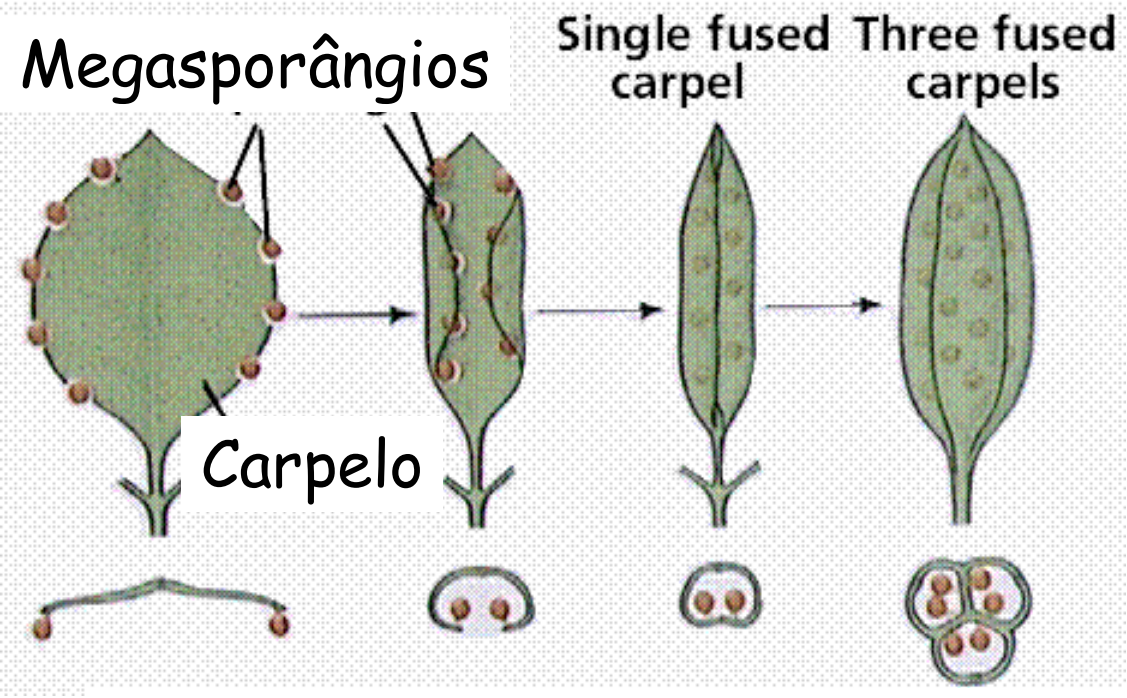
Legume

Ovário unicarpelar, resultando num fruto seco, **Indeiscente**, uniovulado

Cariopse

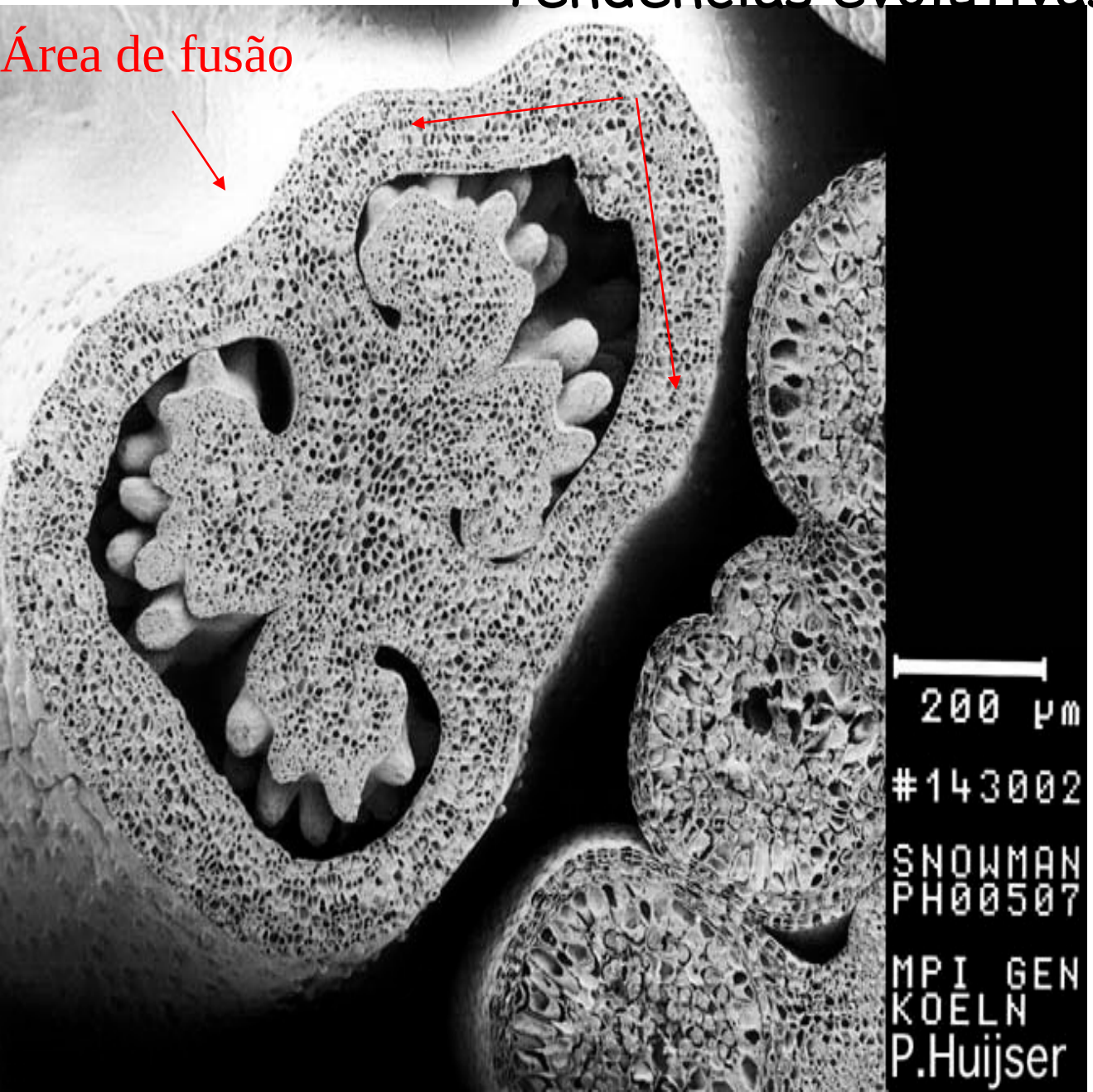
Aquênio

Tendências evolutivas - Gineceu



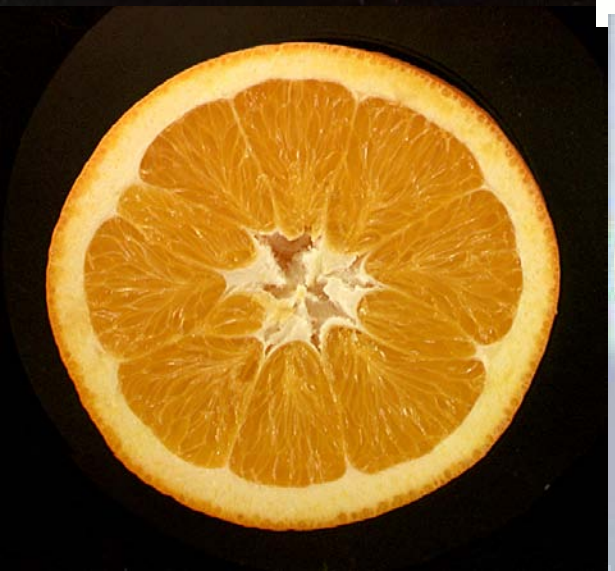
Carpelos conduplicados
E Fusionados (=CONCRESCIDOS),
FORMANDO SEPTOS E LÓCULOS

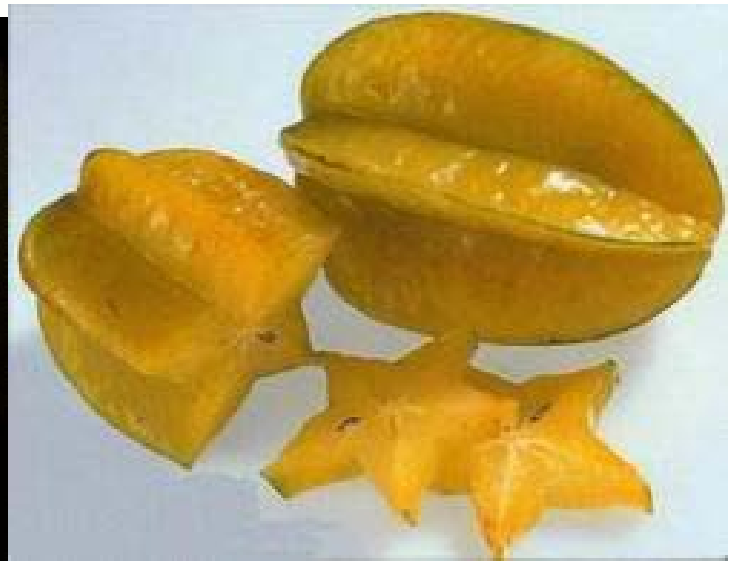
Tendências evolutivas - Gineceu



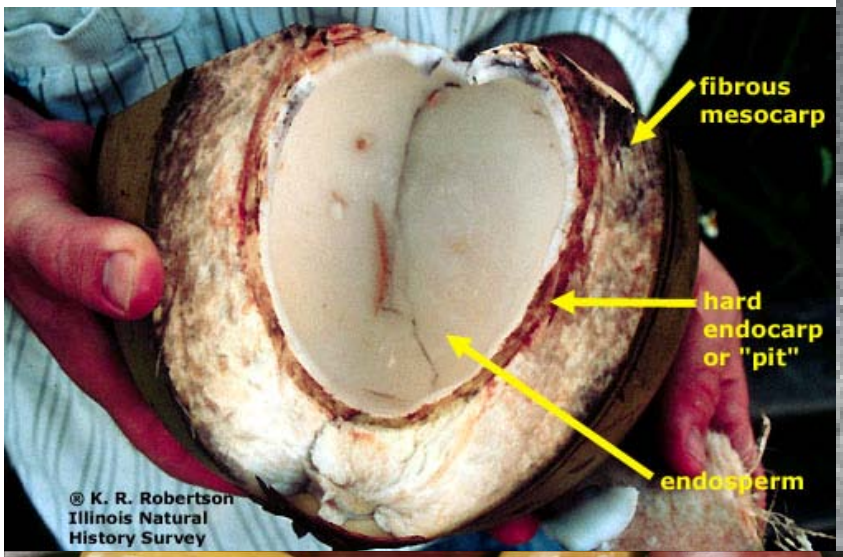
Carpelos conduplicados fusionados

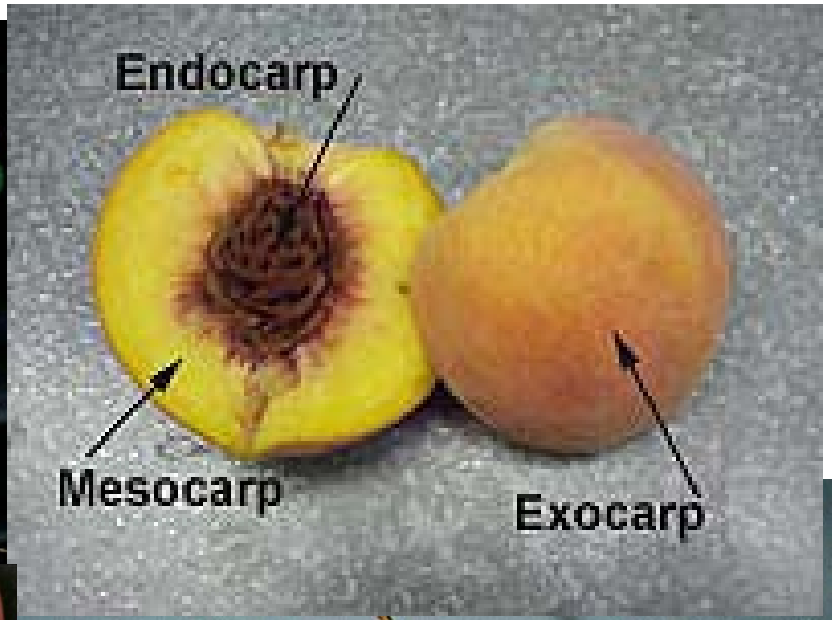
Gineceu com carpelos concrescidos, placentação axial, resultando em frutos carnosos - BAGAS

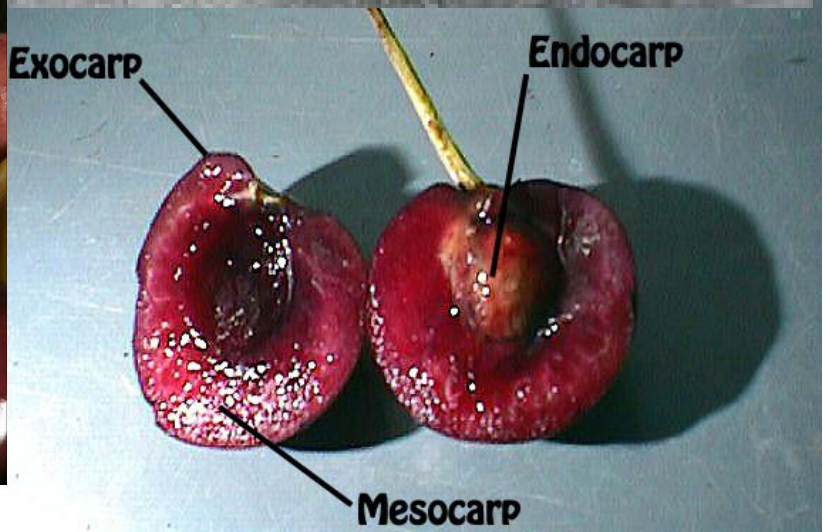




Gineceu com carpelos concrescidos, placentação axial, resultando em frutos carnosos com endocarpo rígido - **DRUPAS**

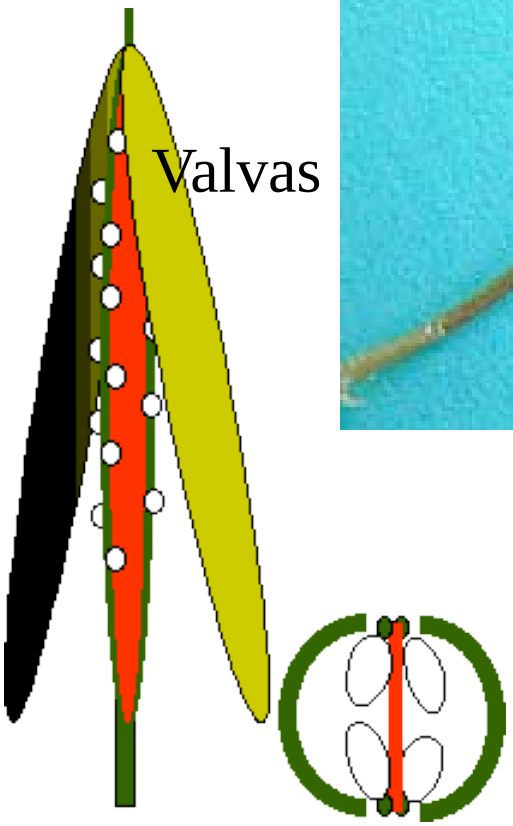






Gineceu com carpelos concrescidos, placentação axial, resultando em frutos secos deiscentes - cápsulas

Gineceu com carpelos concrescidos, placentação axial, resultando em frutos secos deiscentes - sílicas



Gineceu com carpelos concrescidos, placentação axial, resultando em frutos secos indeiscentes - sâmara, noz

Gineceu

Placentação central livre

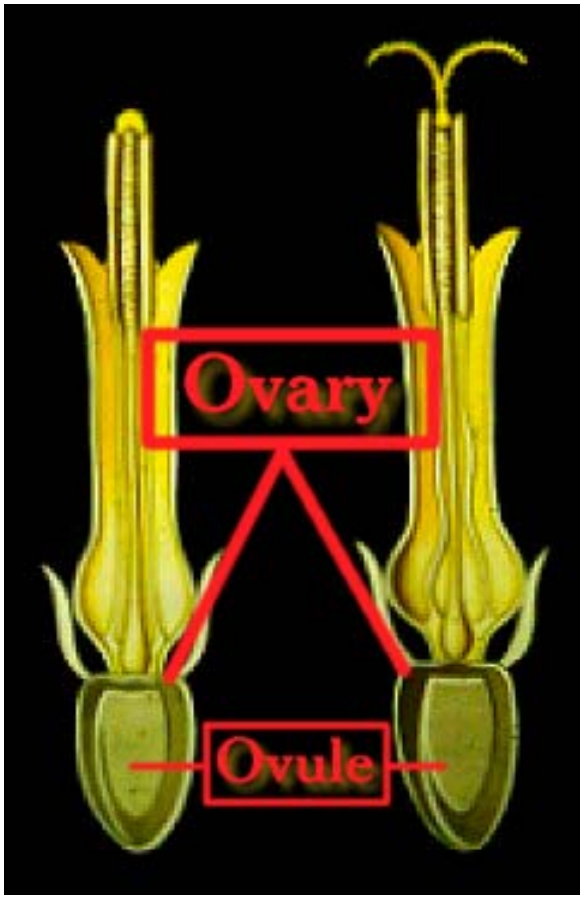
Chenopodium

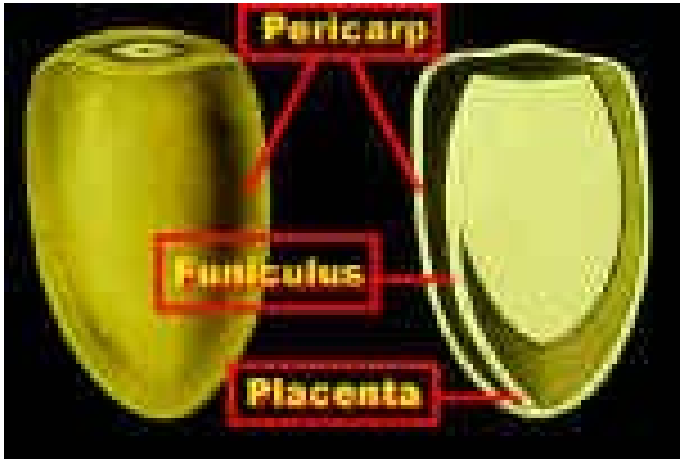
Spinacia

Berberidaceae - *Berberis*

Gineceu

Placentação basal





Tipos de ovários/placentação

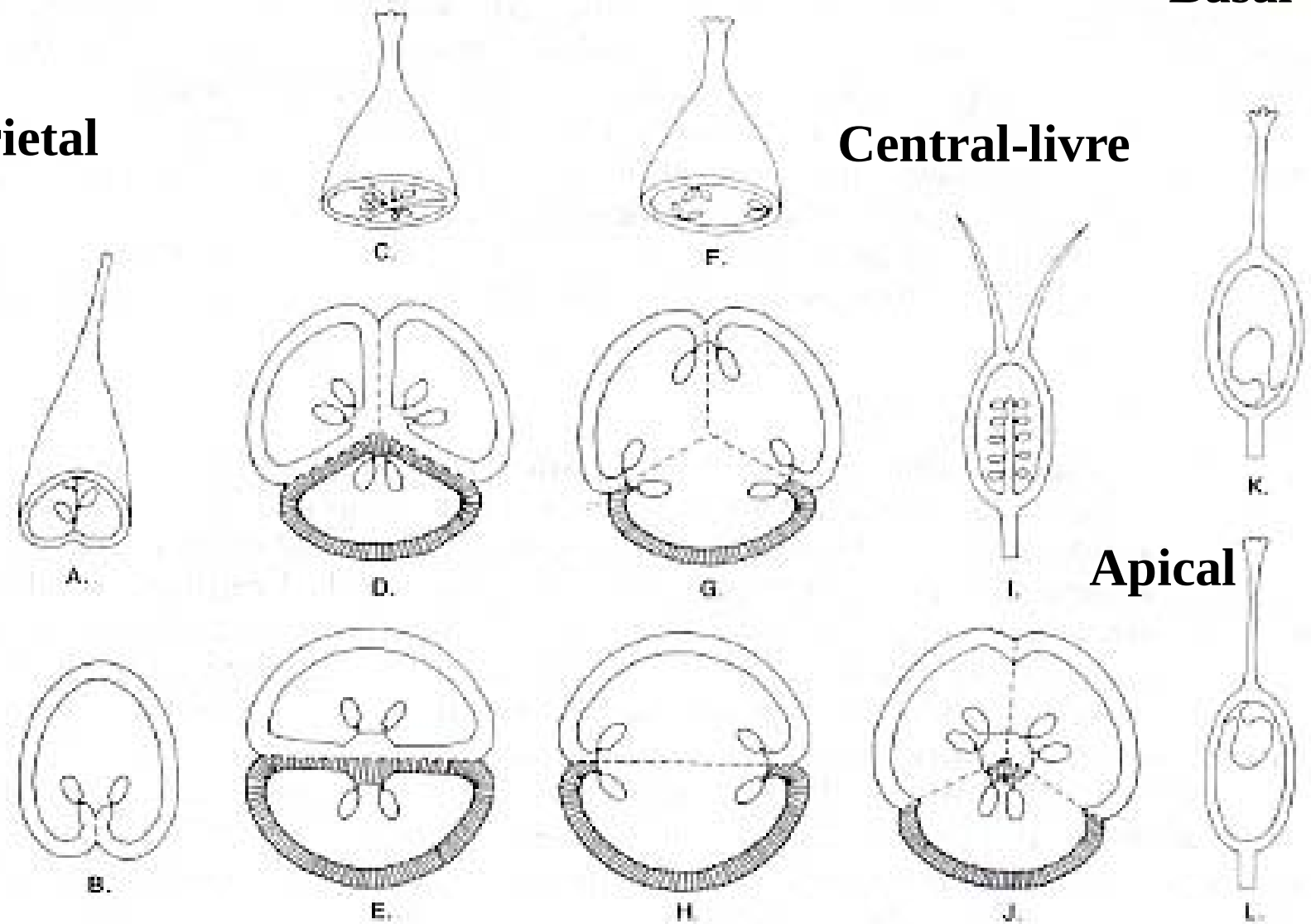
Axial

Parietal

Basal

Parietal

Central-livre



Apical

Bibliografia

Judd,W.S. et al. 2009. Sistemática Vegetal; um enfoque filogenético. Espermatófitas pp. 168- 184.

Pirani, J.R. et al. Magnoliopyta (Angiospermae). 2001. Origem das Angiospermae. Apostila USP.

Raven et al. 2007. Biologia vegetal. Cap. 19 - Introdução às Angiospermas; Cap. 20- Evolução das Angiospermas . pp. 452-492. Guanabara Koogan, Rio de Janeiro.

http://www.gigantopteroid.org/html/research.htm

[Paleobotany of Angiosperm Origins]

JOHN M. MILLER, PH.D.

Having discussed the origin of angiosperms from shrub-like Carboniferous or Permo-Triassic seed plant stock I outline and discuss the biodiversity and paleontology of extinct Paleozoic vascular plants and their phytophagous insect associates, which is necessary to solve the riddle of angiosperm beginnings within a coevolutionary and phylogenetic context.

Is there convincing fossil evidence of the first flowering plants or their antecedents? No, according to E. L. Taylor and T. N. Taylor (2009).

Based on studies published by protein biochemists (Burmester 2004), I concluded that molecular evolution of invertebrate hemocyanin enzymes and their derived insect hexamerins was probably driven by the rise and fall of oxygen in the Earth's atmosphere at two intervals during the Paleozoic Era. Phytophagous insects might have used oxygen-generating vegetation of hypoxic Paleozoic times as a source of food and for shelter from cold and ultraviolet radiation (Labandeira 2006).

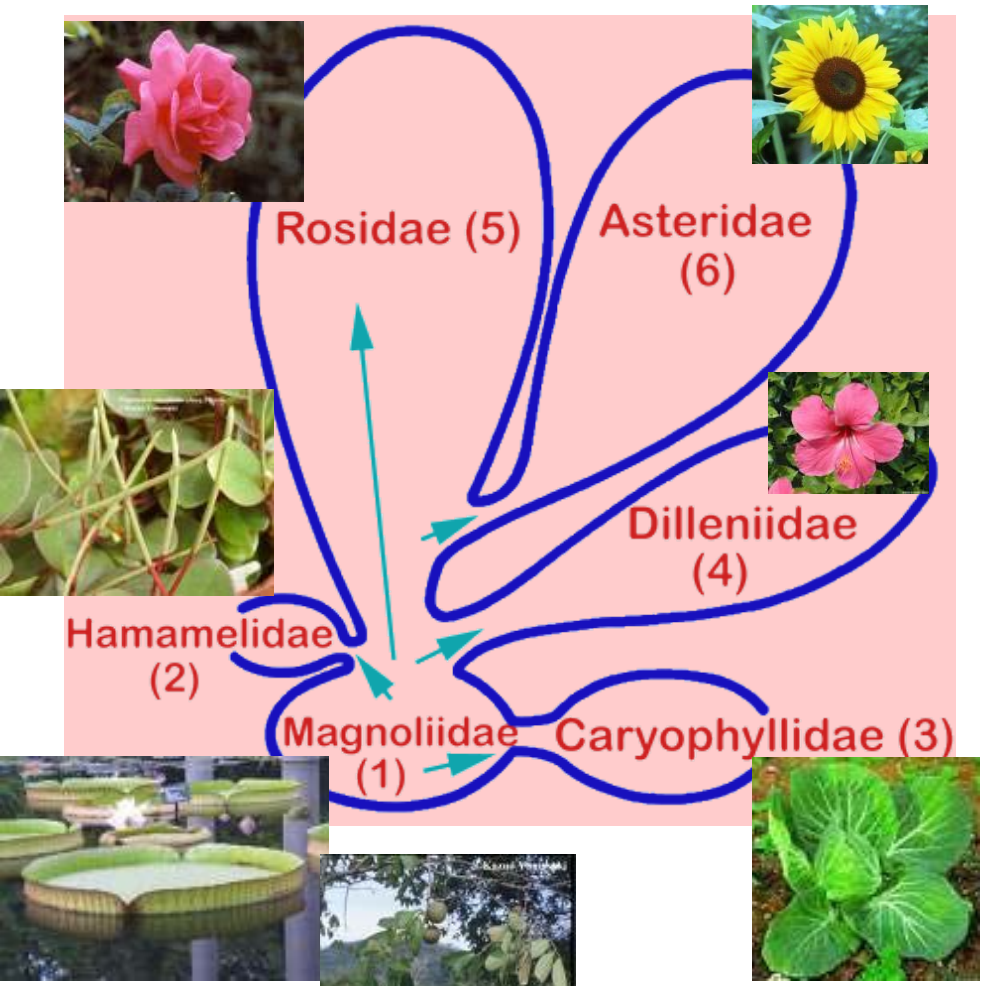
I also proposed that insect-seed plant interactions affected by temperature extremes and global hypoxia in Paleozoic terrestrial biomes led to diversification at the molecular level in early seed plant and holometabolous insect lineages, evolutionary development of flowers from bisexual cone axes following a Theißen and Saedler (2001) or Baum and Hileman (2006) model of protein quartets, and developmental innovations in clades of early holometabolous insects.

Further, I hypothesized that phytoecdysones secreted by Permo-Carboniferous and Permo-Triassic shrub lifeboats potentially affected body size and moulting time of phytophagous insect antagonists.

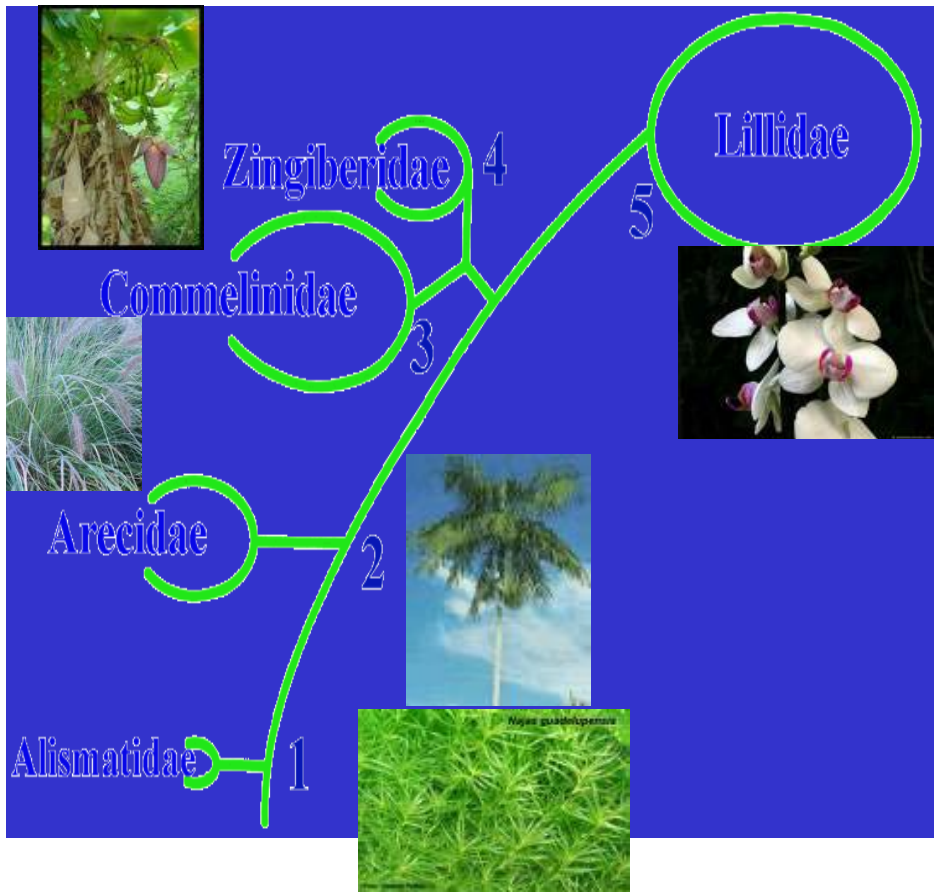
Cronquist 1988

Divisão: Magnoliophyta

Classe: Magnoliopsida = Dicots



Classe: Liliopsida = Monocots



Angiospermae

Soltis, Soltis, Edward 2005